SOIL SURVEY

Holt County Missouri

Series 1939, No. 21

Issued December, 1953

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Conservation Service

In cooperation with the

UNIVERSITY OF MISSOURI AGRICULTURAL EXPERIMENT STATION

How to Use THE SOIL SURVEY REPORT

FARMERS who have worked with their soils for a long time know about soil differences on their own farms, and perhaps about differences among soils on farms of their immediate neighbors. What they do not know, unless soil surveys have been made, is how nearly their soils are like those on experiment stations or other farms, either in their State or other States, where farmers have gained experience with new or different farming practices or enterprises. The farmers of Holt County can avoid some of the risk and uncertainty involved in trying new crop and soil management practices by using this soil survey report, for it maps and describes the soils in their county and therefore allows them to compare the soils on their farms with soils on which new developments have proved successful.

SOILS OF A PARTICULAR FARM

All the soils in Holt County are shown on the map placed in the envelope inside the back cover of this report. To learn what soils are on a farm (or any tract of land) it is first necessary to locate it on the map. To do this find the general locality the farm is known to be in; then use township and section lines and roads, streams, villages, dwellings, or other landmarks to locate its boundaries. Remember that an inch on the map equals a mile on the ground.

The next step is to identify the soils on the farm. Suppose, for example, one finds on a farm an area marked with the symbol Mm. Look among the rectangles in the margin of the map and find the one with Mm printed on it. Just above this rectangle is the name of the soil—McPaul silt loam.

What is McPaul silt loam like, for what is it used, and to what uses is it suited? This information will be found in the section on Soil Types, Phases, and Land Types. The particular pages on which McPaul silt loam is discussed can be found by referring to the table of contents. How productive is this soil? The answer will be found in table 8. Find in the left-hand column of this table the name McPaul silt loam and read, in the columns opposite, the yields of different crops this soil can be expected to produce under two levels of management—average and good. Compare these yields with those given in the table for other soils of the county.

What uses and management practices are recommended for McPaul silt loam? Part of this information is given in the section on Soil Types, Phases, and Land Types, where each soil is described. The rest will be found in the section on Use and Management of Important Groups of Soils, in which soils suited to the same use and management are grouped together. McPaul silt loam is in the group of Medium-Textured Soils of Bottom Lands Not Subject to Frequent Severe Floods. What is said about fertilizing, tilling, and protecting this group of soils from floods applies to McPaul silt loam.

SOILS OF THE COUNTY AS A WHOLE

A general idea of the soils of the county is given in the introductory part of the section on Soils, which tells about the principal kinds of soils, where they are found, and how they are related to one another. After reading this section study the soil map and notice how the different kinds of soils tend to be arranged in different parts of the county. These patterns are likely to be associated with well-recognized differences in type of farming, land use, and land use problems.

A newcomer to the county, especially if he considers purchasing a farm, will want to know about the climate; the types and sizes of farms; the principal farm products and how they are marketed; kinds of farm buildings, equipment, and machinery; availability of churches, schools, roads, railroads, telephones, electrical services, and water supplies; the industries of the county; and cities, villages, and population characteristics. Information about all of these will be found by referring to the table of contents.

Those interested in how the soils of the county were formed and how they are related to the great soil groups of the world should read the section on Morphology, Genesis, and Classification of Soils.

This publication of the soil survey of Holt County, Mo., is a cooperative contribution from the—

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SOIL SURVEY OF HOLT COUNTY, MISSOURI

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United States Department of Agriculture in Cooperation With the University of Missouri Agricultural Experiment Station

CONTENTS

[1] The Division of Soil Survey was transferred to the Soil Conservation Service on November 15, 1952.

HOLT COUNTY is a fertile agricultural area in northwestern Missouri used principally for field crops and livestock. The western part—about 40 percent of the total area—consists of bottom lands. Corn is the leading crop in this area, though large acreages of fine-textured soil not suitable for corn are planted to wheat. Drainage and flood control are the principal problems on the bottom lands. Bordering the bottom lands on the east is the Missouri River bluff, on which lies a narrow belt of hilly upland prairie soils. These hilly soils grade into a large area of rolling dark-colored upland prairie soils that continues eastward to the county line. The upland soils are used for corn, wheat, alfalfa, red clover, and bluegrass. The steeper areas are pastured. All the upland soils need additional organic matter, and some need lime and fertilizer, but erosion control is the most critical problem. Erosion must be controlled before other soil-building practices can be successful. To provide a basis for determining the best agricultural uses of land, this cooperative survey was completed in 1939 by the United States Department of Agriculture and the University of Missouri Agricultural Experiment Station. Unless otherwise specifically mentioned, all statements in this report refer to conditions in the county at the time of survey.

GENERAL NATURE OF THE AREA

LOCATION AND EXTENT

Holt County, near the northwestern corner of Missouri, is bounded on the west and south by the Missouri River, which separates it from Kansas and Nebraska. On the north it is bordered by Atchison and Nodaway Counties. Oregon, the county seat is 20 miles northwest of St. Joseph and 280 miles northwest of St. Louis (fig. 1). The approximate area of the county is 459 square miles, or 293,760 acres.

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

Over 40 percent of the county is bottom land, which covers the entire western and southern sides in tracts 2 to 12 miles wide. This is the Missouri River flood plain.

The upland rises abruptly as a bluff as much as 250 feet above the Missouri River flood plain. This band of "river hill land" averages about 2 miles wide but in the southern part of the county is 5 miles or more wide. Wide differences in elevation between bottom land and upland have resulted in thorough dissection of the hills bordering the flood plain. Much of this steeply sloping land has gradients of 15 to 25 percent, and on the bluff, gradients of 60 to 90 percent are not uncommon. These hills are mantled with loess[2]—a silty windblown deposit—which in places near the flood plain is 100 feet or more thick. In the southern part the loess is thinnest. Rock outcrops are rare, even on the steepest slopes.

To the east the deeply dissected river hills blend into a rolling prairie having slopes of 2- to 10-percent gradient and narrow rounded ridges.

[2] Loess is unconsolidated silty material picked up by the wind on the Missouri River flood plain in ages past and deposited on the neighboring upland.

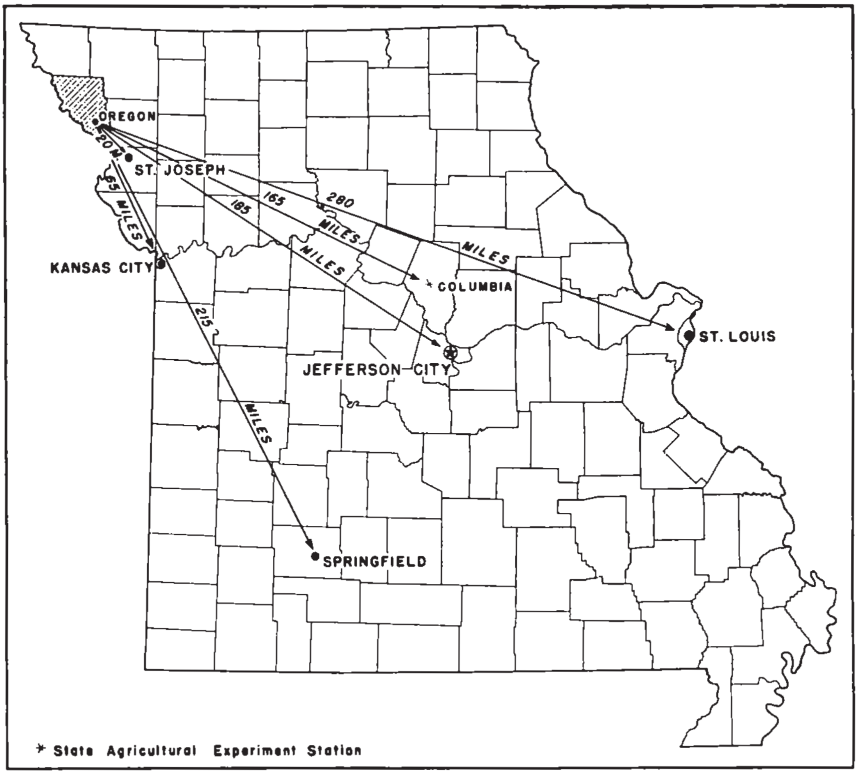

FIGURE 1.—Location of Holt County in Missouri.

A divide of approximately 1,100 feet elevation extends across the entire county from north to south, separating the watersheds of the Nodaway and the Missouri Rivers. The highest elevation in the county is 1,152 feet near the southern end of this divide.

At the bench mark at Forest City the elevation is 858 feet; at Oregon, 2½ miles east, 1,094 feet; and at Mound City, 880 feet on the western edge of the town to 1,020 feet in the eastern part. The elevation of the Missouri River flood plain ranges from 830 feet at Forbes to 875 feet at Corning, 45 miles upstream. The Nodaway River has an elevation of 901 feet at Maitland, and at its junction with the Missouri River, 830 feet.

The principal drainage basins of the county are shown in figure 2. About two-thirds of the upland drains directly into the Missouri River; the eastern one-third, into the Nodaway River. The Big Tarkio River, flowing through a dug canal for about 9 miles before joining the Missouri, drains less than a square mile of the upland in this county. The Big Tarkio River rises about 90 miles to the north in Montgomery County, Iowa. Little Tarkio Creek rises in Atchison County, Mo., and drains 20 square miles of Holt County. It flows through the Missouri River bottoms for about 15 miles before entering that river south of Fortescue. Squaw Creek drains about 50 square miles in the county. It once flowed into the Missouri River

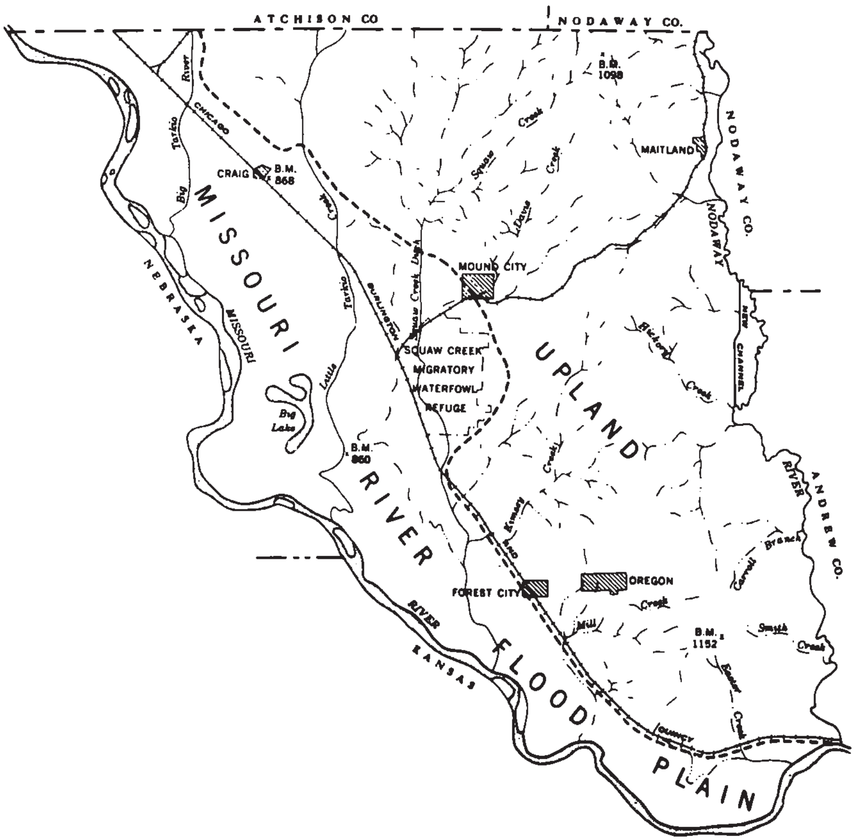

FIGURE 2.—General drainage map of Holt County, Mo.

flood plain a short distance above Mound City and spread out to form a marsh referred to as Impassable Lake. Its waters are now carried by a system of ditches through the Squaw Creek Migratory Waterfowl Refuge and enter the Missouri River southwest of Forest City.

GEOLOGY

Brown silty material known as loess covers the river hills to a considerable depth. As the distance from the bluff along the Missouri River increases, the loess thins rapidly. In places near the bluff the loess appears to be 100 feet or more thick. In other parts of the county it is only about 10 feet thick on the broader ridges and entirely absent on steeper slopes.

Glacial till, or boulder clay, underlies the loess and over most of the upland is exposed on steeper slopes. This glacial till is a heterogeneous mixture of clay, sand, gravel, and large boulders deposited by glaciers during the ice age. The land surface on which the till was deposited was not level but had many hills and valleys. The glacial deposit was not uniform over the entire county, but it tended to smooth out some of the land surface. In the north-central part

the till is 40 feet or more thick, but from New Point south to the river bluffs it outcrops through the loess as bands 2 to 6 feet thick.

There are no level upland areas. Loess covers all of the land near the bluffs, but farther away glacial till and sedimentary rocks (dominantly shales but also thin beds of limestone and sandstone) are in a few places exposed on the slopes.

WATER SUPPLY

The supply of ground water is intimately related to the geology of the region. On the uplands rain water passes readily through the loose silty loess to the underlying glacial clay. The clay is less pervious than the loess material, so water collects in intermittent veins where the loess and glacial till are in contact.

Well drillers report two glacial deposits in the northern part of the county. Some percolating water passes through the upper layer of glacial clay and collects in pockets of sand and gravel in the lower glacial materials. In other places, veins of water are found where the till is in contact with the underlying country rock. There are some veins of water in the country rock, but wells have been dug several hundred feet deep without striking a good vein.

At the time of settlement there were many small springs, and where these were not conveniently located, wells dug near the farm home supplied water for household use. During the time of survey most of the springs flowed only in wet weather, and many of the wells were dry.

VEGETATION

Originally there were five distinct vegetative regions in the county as shown in figure 3 and explained in the numbered paragraphs following.

1. The upland forest region, originally covering about 25 percent of the county, had a wide variety of trees and shrubs, including bur, Southern red, and white oaks, black walnut, shellbark and pignut hickories, and American elm. Considerable grass grew in association with the forest vegetation.

2. Bottom land forest covered about 70 percent of the Missouri River flood plain, chiefly the sandier land adjoining the Missouri River.

3. Bottom land marsh vegetated with swamp grass and sedges covered large treeless areas of heavy gumbo land totaling about 60 to 70 square miles on the Missouri River flood plain. Most of this gumbo land was flooded part of each year, and some of it was constantly covered by water.

4. On the upland prairie region, occupying about 35 percent of the county, the dominant grasses were big bluestem, little bluestem, and some coarse swamp grasses in the drainageways.

5. The bluff grassland areas have a dry-land type of vegetation. This vegetation was native to and still occupies the steep bluffs, particularly on the south- and west-facing slopes that border the Missouri River flood plain in the central part of the county. The deep loose soils of this area dry out to great depth, so only a sparse growth of

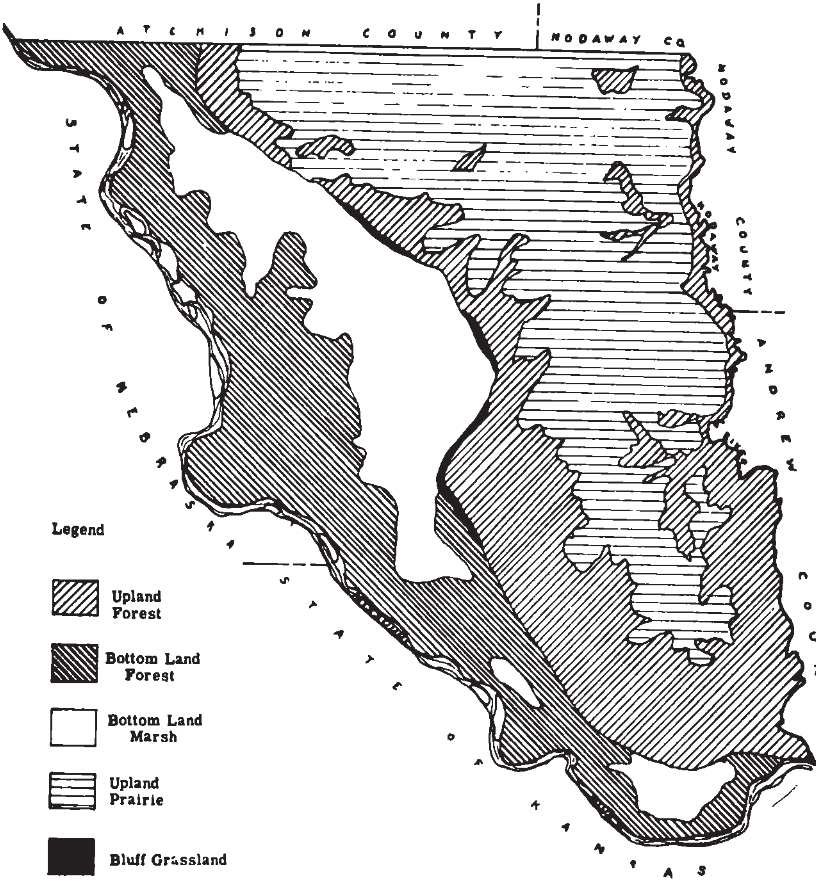

FIGURE 3.—Natural vegetative areas in Holt County, Mo.

side-oats grama and other drought-resistant deep-rooting grasses can survive. In places a few sumac grow but seldom to a height of more than 4 to 5 feet (fig. 4).

CLIMATE

The climate is continental, with the maximum rainfall in summer. There are wide seasonal, monthly, and even daily variations in temperature, but extremes are not so great as in States farther west and north. Normal monthly, seasonal, and annual temperatures and precipitation considered representative of climatic conditions in the county are listed in table 1.

As shown in table 1, the average January temperature is 24.1° F., and the average July temperature is 75.6°. The extreme low temperature recorded is −26°; the highest, 110°. Extreme high and low temperatures are of short duration. Low winter temperatures come as cold waves sweeping out of the northern plains region and are often accompanied by snow and wind. The St. Joseph weather station near the southern edge of the county reports an average of 7 days

a year with temperatures below zero. Freezing temperatures occur on the average of 108 days a year. The temperature starts rising rapidly in April and reaches a peak in July. On the average there are 40 days a year with temperatures above 90°.

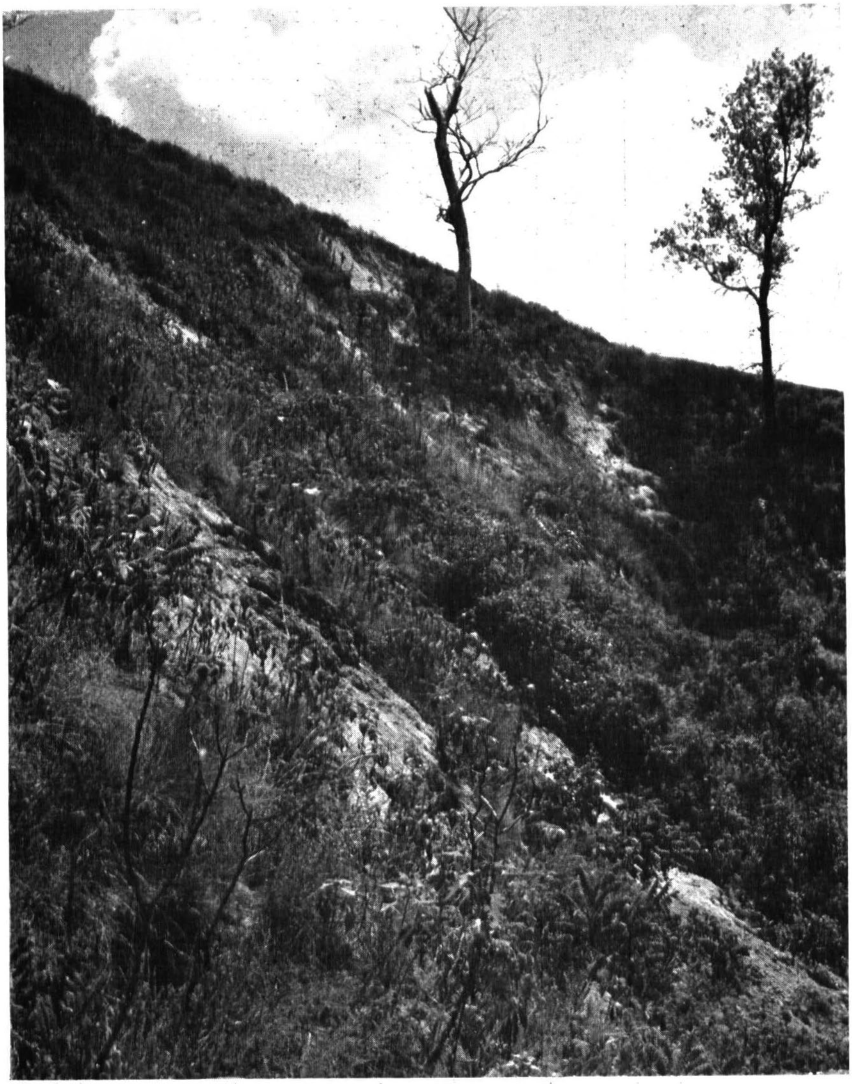

FIGURE 4.—Bare slumped areas and typical sparse native vegetation, dominantly side-oats grama and sumac, on steep bluffs in Holt County, Mo.

The average date of the last killing frost in spring is April 17; the first in fall, October 16. The average growing season is 181 days, but frost dates vary from year to year. Even the shortest frost-free season (150 days) is sufficient to mature corn, and the variable frost dates do not seriously disrupt the type of farming practiced. Fruit-growing areas, however, may be affected. Peaches and, to less extent,

apples are seriously damaged in years with extremely late spring frosts. The grazing season, slightly longer than the growing season, lasts from May to December.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Oregon, Holt County, Mo.*

[Elevation, 1,048 feet]

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Total for the driest year	Total for the wettest year	Average snowfall
	°F.	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	28. 7	73	−19	1. 04	0. 67	2. 41	4. 0
January	24. 1	70	−26	. 93	1. 93	1. 38	5. 2
February	28. 8	84	−26	1. 37	. 34	. 44	5. 8
Winter	27. 2	84	−26	3. 34	2. 94	4. 23	15. 0
March	39. 6	91	−7	1. 96	([3])	. 87	4. 3
April	52. 7	95	11	3. 29	1. 42	1. 30	1. 4
May	63. 2	95	25	4. 53	7. 41	6. 42	. 1
Spring	51. 8	95	−7	9. 78	8. 83	8. 59	5. 8
June	72. 2	102	42	5. 37	2. 66	7. 52	0
July	75. 6	108	47	4. 18	. 47	10. 77	0
August	75. 2	110	41	3. 80	1. 65	4. 42	0
Summer	74. 3	110	41	13. 35	4. 78	22. 71	0
September	67. 1	102	30	5. 10	4. 28	7. 69	0
October	55. 1	94	3	2. 75	. 38	4. 72	. 9
November	40. 5	83	−10	1. 98	. 20	2. 80	1. 3
Fall	54. 2	102	−10	9. 83	4. 86	15. 21	2. 2
Year	51. 9	110	−26	36. 30	21. 41	[5] 50. 74	23. 0

[1] Average temperature based on 95-year record, 1856 to 1950; highest and lowest temperatures from 40-year period, 1891 to 1930.
[2] Average precipitation based on 95-year record, 1856 to 1950; driest and wettest years based on 96-year record, 1855 to 1950; snowfall on 41-year record, 1890 to 1930.
[3] Trace.
[4] In 1910.
[5] In 1902.

At Oregon, in the southern part of the county, the average annual precipitation is 36.3 inches, much of which falls during the growing season. The average rainfall for the five summer months, May through September, is 22.98 inches, or nearly 66 percent of the average annual precipitation.

If precipitation during the growing season did not deviate from monthly averages shown in table 1 and were evenly distributed, the county would have almost an ideal amount of moisture for plant growth. Unfortunately, the distribution of rainfall is uneven.

Much of it comes as thunderstorms; extremely heavy downpours are not uncommon. At St. Joseph as much as 0.96 inch of rainfall has been reported for a 10-minute period, and the maximum reported for a 24-hour period is 6.53 inches. A downpour may be followed by a period in which rainfall is deficient. A 10-day period in summer with less than an inch of rain is considered one of moisture deficiency, and according to a study of northwestern Missouri made by the Missouri Agricultural Experiment Station, such deficiencies occurred in June, July, or August for 18 out of 20 years in the period 1919–38. In 1936, for example, during the 45-day period July 1 to August 15, there was not a time when an inch of rain had fallen within the preceding 10 days. Also, out of this 20-year period, there were 10 summers when moisture was deficient for 20 successive days. Usually a slight amount of rain falls during such periods of extreme drought, but never enough for crop needs. At St. Joseph the average is 52 days a year with thunderstorms, 100 days with more than 0.01 inch of rainfall, and 36 days with snow. About half of the winter precipitation comes as snow.

Cloudiness and relative humidity are highest in winter, though precipitation is lowest in that season. In winter the sun shines only 55 percent of the time; in summer, 74 percent. The noon relative humidity is 63 percent in winter, as compared to 51 percent in spring, 53 percent in summer, and 54 percent in autumn. The prevailing winds are from the south or southeast in summer and from the northwest in all other seasons. Tornadoes and destructive hailstorms, spectacular but rare occurrences in this region, seldom affect more than a small area.

SOILS

Most Holt County soils are dark colored, deep, and highly fertile. They have these characteristics because they have developed under a prairie vegetation from material rich in plant nutrients. They belong to the group of dark soils characterizing northwestern Missouri and also to the larger agricultural region known as the Corn Belt. There are two physiographic areas in the county, the upland and the river bottoms. The following tabulation shows to which of these areas the soils of the county belong, their parent material, and their slope range.

- I. Upland soils:
  - A. From loess:
    - 1. Brown soils:
      - Hamburg very fine sandy loam (30–50% slopes).
      - Knox silt loam:
        - Sloping light-textured subsoil phase (4–9% slopes)
        - Strongly sloping light-textured subsoil phase (9–19% slopes).
        - Steep light-textured subsoil phase (19–30% slopes).
        - Sloping phase (4–12% slopes).
        - Strongly sloping phase (12–20% slopes).
    - 2. Dark-brown soils:
      - Marshall silt loam:
        - Undulating phase (2–6% slopes).
        - Sloping phase (6–8% slopes).
        - Eroded sloping phase (8–13% slopes).
        - Undulating brown phase (3–7% slopes).
        - Sloping brown phase (7–10% slopes).
        - Eroded strongly sloping brown phase (8–15% slopes).

Sharpsburg silty clay loam:
- Undulating phase (1–6% slopes).
- Sloping phase (6–9% slopes).
- Eroded sloping phase (6–9% slopes).

B. From glacial till:

Shelby loam:
- Sloping phase (5–12% slopes).
- Eroded sloping phase (6–12% slopes).
- Strongly sloping phase (12–19% slopes).

Shelby silt loam:
- Sloping phase (5–9% slopes).
- Eroded sloping phase (6–12% slopes).

Moderately steep land (Shelby soil material) (7–19% slopes).

C. From shales and limestones:

Mandeville silt loam:
- Sloping phase (7–12% slopes).
- Moderately steep phase (12–20% slopes).

Steep stony land (Mandeville soil material) (20–50% slopes)

II. Bottom land and terrace soils:

A. Sandy or coarse-textured soils:

Sarpy loamy very fine sand (0–2% slopes).
- Overflow phase (0–2% slopes).

Riverwash (0–2% slopes).

B. Medium-textured soils:

Sarpy very fine sandy loam (0–2% slopes).
- Overflow phase (0–2% slopes).

McPaul silt loam (0–4% slopes).

McPaul very fine sandy loam (0–2% slopes).

Wabash silt loam (0–6% slopes).

Napier silt loam:
- Gently sloping phase (1–7% slopes).
- Sloping phase (7–15% slopes).

C. Fine-textured soils:

Cass clay (0–1% slopes).

Cass silty clay (0–1% slopes).

Wabash silty clay loam (0–1% slopes).

Wabash clay (0–1% slopes).
- Ponded phase (0–1% slopes).

TABLE 2.—*Holt County, Missouri, soils: Summary of important characteristics*

Soil	Map symbol	Dominant slope	Permeability		Occurrence of high water table	Severity of flood	Erosion hazard	Workability	Resistance to drought	Natural fertility	Lime need
			Surface soil	Subsoil							
		Percent									
Cass clay	Cc	0–1	Slow	Rapid	Present in places during high water.	Moderate	None	Fair to poor	Fair for wheat; poor for corn.	High	None.
Cass silty clay	Cs	0–1	Moderately slow.	do	do	do	do	Fair	Fair	do	Do.
Hamburg very fine sandy loam.	Hv	30–50	Rapid	do	None	None	Very severe if cultivated.	Difficult because of steep slopes.	Poor	High, except in organic matter.	Do.
Knox silt loam:											
Sloping phase	Kss	4–12	Moderately rapid.	Moderate	do	do	Moderately severe.	Good	Fair	Moderate	Slight.
Sloping light-textured subsoil phase.	Ksx	4–9	do	Moderately rapid.	do	do	Moderate	do	do	Moderately high.	None.
Steep light-textured subsoil phase.	KsL	19–30	do	do	do	do	Very severe	Fair	do	High, except in organic matter.	Do.
Strongly sloping phase	KsT	12–20	do	Moderate	do	do	Severe	Good	do	Moderate	Do.
Strongly sloping light-textured subsoil phase.	KsR	9–19	do	Moderately rapid.	do	do	do	do	do	High, except in organic matter.	Do.
Mandeville silt loam:											
Moderately steep phase	Msm	12–20	do	Moderately slow.	do	do	Very severe	Fair	do	Moderate	Slight to moderate.
Sloping phase	Mss	7–12	do	Slightly restricted.	do	do	Severe	do	do	do	Do.
Marshall silt loam:											
Eroded sloping phase	MLE	8–13	do	Moderate	do	do	do	do	Fair to poor.	Low in organic matter; moderate in other nutrients.	Do.
Eroded strongly sloping brown phase.	MLD	8–15	do	Moderately rapid.	do	do	Very severe	do	do	do	Very slight.

TABLE 2.—*Holt County, Missouri, soils: Summary of important characteristics*—Continued

Soil	Map symbol	Dominant slope	Permeability		Occurrence of high water table	Severity of flood	Erosion hazard	Workability	Resistance to drought	Natural fertility	Lime need
			Surface soil	Subsoil							
Marshall silt loam—Continued		*Percent*									
Sloping phase	MLS	6-8	Moderately rapid.	Moderate	None	None	Moderately severe.	Good	Good	High	Slight.
Sloping brown phase	MLW	7-10	do.	Moderately rapid.	do.	do.	do.	do.	do.	do.	Very slight.
Undulating phase	MLU	2-6	Moderate	Moderate	do.	do.	Slight to moderate.	do.	do.	do.	Slight.
Undulating brown phase	MLN	3-7	Moderately rapid.	Moderately rapid.	do.	do.	Slight	do.	Fair	do.	Very slight.
McPaul silt loam	MM	0-4	do.	Slow	Variable	Frequent brief floods if not protected by levees.	None	do.	Very good	do.	None.
McPaul very fine sandy loam	MV	0-2	do.	Moderate	do.	Moderately severe.	do.	do.	do.	do.	Slight.
Moderately steep land (Shelby soil material).	MTS	7-19	do.	do.	None	None	Severe	do.	Fair	do.	None.
Napier silt loam:											
Gently sloping phase	NSG	1-7	do.	do.	do.	Slight, from small streams.	Slight	do.	Good	do.	Do.
Sloping phase	NSS	7-15	do.	do.	do.	None	Moderately severe.	do.	do.	do.	Do.
Riverwash	RV	0-2	Rapid	Rapid	Variable	Very severe	None	Variable	Variable	Variable	Do.
Sarpy loamy very fine sand	SD	0-2	do.	do.	None	Moderate	Some wind erosion.	Good	do.	Moderate	None to slight.
Overflow phase	SDO	0-2	do.	do.	Variable	Severe	do.	do.	do.	do.	None.
Sarpy very fine sandy loam	SV	0-2	do.	do.	None	Slight to moderate.	None	Very good	Good	High	Do.
Overflow phase	SVO	0-2	do.	do.	Variable	Severe	do.	do.	do.	do.	Do.
Sharpsburg silty clay loam:											
Eroded sloping phase	SSE	6-9	Moderate	Moderate	None	None	Severe	Fair	Fair	Low in organic matter; moderate in other nutrients.	Moderate
Sloping phase	SSS	6-9	do.	do.	do.	do.	do.	Good	Good	High	Do.
Undulating phase	SSU	1-6	do.	do.	do.	do.	Moderate	do.	do.	do.	Do.

Shelby loam:											
Eroded sloping phase	SLE	6-12	Moderately slow.	Moderately slow.	do.	do.	Very severe.	Poor	Poor	Low	Moderately high.
Sloping phase	SLS	5-12	Moderately rapid.	do.	do.	do.	Severe	Good	Fair	Moderate	Moderate.
Strongly sloping phase	SLT	12-19	Moderate	Slow	do.	do.	Very severe.	Fairly poor	do.	do.	Do.
Shelby silt loam:											
Eroded sloping phase	SBE	6-12	Moderately slow.	Moderately slow.	do.	do.	do.	do.	Poor	Low	Moderately high.
Sloping phase	SBS	5-9	Moderately rapid.	do.	do.	do.	Severe	Good	Fair	Moderate	Moderate.
Steep stony land (Mandeville soil material).	StM	20-50	Variable	Variable	do.	do.	Severe if vegetation is removed.	Too stony and steep for cultivation.	Fair to poor	Low	----
Wabash clay	Wc	0-1	Slow	Slow	Variable	Moderate	None	Fair to poor	Fair for wheat; poor for corn.	High	Slight.
Ponded phase	WcP	0-1	do.	do.	Severe problem.	Very severe	do.	Poor	Fair	do.	Do.
Wabash silt loam	Ws	0-6	Moderately rapid.	Moderately slow.	Not generally present.	Moderate	do.	Good	Good	do.	Do.
Wabash silty clay loam	WL	0-1	Moderate	do.	Slight problem in some areas	do.	do.	Fair	do.	do.	Do.

Geographic and geologic relationships of the principal soils are brought out in figure 5. The loessal parent material of the Knox, Marshall, and Sharpsburg soils overlies the glacial till from which Shelby soils have formed; Mandeville soils occur only in areas of sedimentary rock outcrop; and the Napier, McPaul, Wabash, Cass, and Sarpy soils have developed in bottom-land areas, chiefly from alluvial materials. A general discussion of the soils of the uplands and bottom lands follows. The important characteristics of each soil are summarized in table 2.

SOILS ON UPLANDS

Ridge tops throughout this county are mantled with loess. West to east, the loess mantle ranges from 100 feet thick on bluffs facing the Missouri River to about 10 feet thick in the eastern part of the county.

The soils formed from the loess are uniformly silty at the surface and have a deep permeable subsoil. Differences in soil types are based primarily on differences in the texture of the subsoil and, to lesser extent, on the color of the surface soil. In the western part of the county the topography is hilly, the loess is thickest, and soils are brown and have indistinct subsoils. Soils in this area are of the Hamburg and Knox series. In the eastern part the topography is rolling, the surface soil is darker, and the subsoil contains more clay than in the western part where Knox soils occur. The dark-colored soils of this eastern part belong to the Marshall and Sharpsburg series.

On some slopes there is no loess mantle. The yellow glacial clay till has been exposed, and from this layer have developed the Shelby soils, which have a relatively thin surface layer and a yellowish-brown clay loam subsoil.

Also, there are some more deeply dissected hilly areas originally forested where underlying sedimentary rocks (shales and sandstones) are exposed. Soils developed from the residuum of these rocks are light brown, shallow, and of the Mandeville series.

Differences in color, texture, and fertility of the soils on the uplands are not marked. The change from one soil to another is generally gradual, there being few sharp lines between soil types. Nearly all the soils have been modified (truncated) by erosion.

SOILS ON BOTTOM LANDS

Bottom land soils, totaling about 40 percent of the county area, are of three textural types: (1) coarse-textured; (2) medium-textured, and (3) fine-textured.

In the coarse-textured group are Sarpy loamy very fine sand and its overflow phase, which occur near the Missouri River and former meanders of that stream. These soils are fertile and intensively used for grain and legume crops.

The soils of the medium-textured group are Sarpy very fine sandy loam and its overflow phase, McPaul silt loam and very fine sandy loam, the gently sloping and sloping phases of Napier silt loam, and Wabash silt loam. The Sarpy soils of this group occur in the river bottoms; the Napier, on alluvial fans and terraces; the Wabash, mainly along smaller streams; and the McPaul, in areas of deposition along

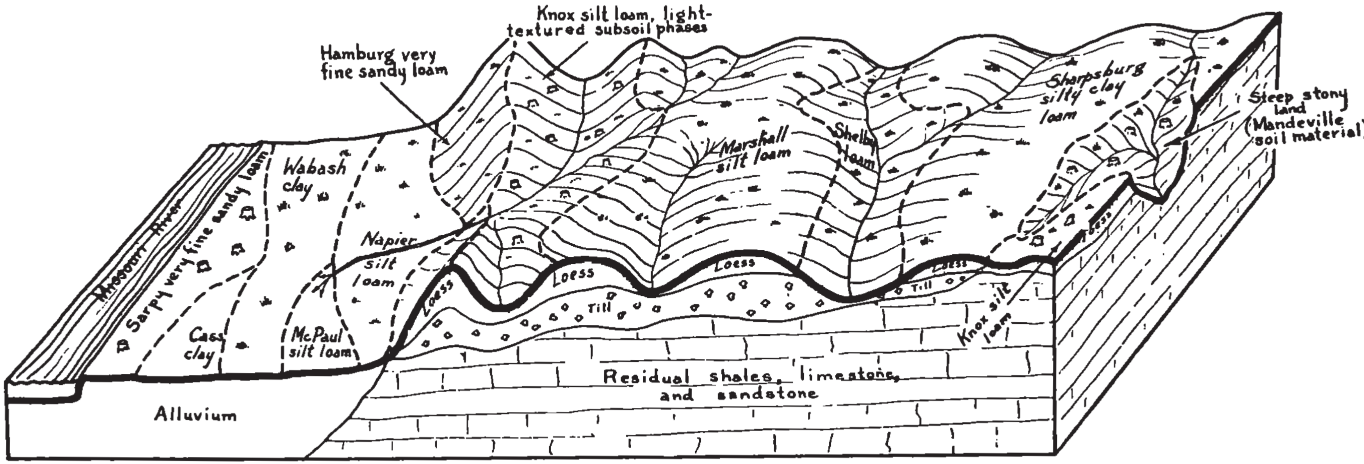

FIGURE 5.—Diagram showing relationships of principal soils in Holt County, Mo.

TABLE 3.—*Estimated average acre yields of principal crops to be expected on soils of Holt County, Mo., under two levels of management*

[Yields in columns A are those to be expected under average management; yields in columns B, those to be expected under good management. (See p. 18 for definitions of average and good management.) Blank spaces indicate soil is not suited to crop specified]

Soil	Map symbol	Corn		Wheat		Oats		Alfalfa		Red clover		Pasture	
		A	B	A	B	A	B	A	B	A	B	A	B
		Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Ton*	*Ton*	*Ton*	*Ton*	*Cow-acre-days* [1]	*Cow-acre-days* [1]
Cass clay	Cc	30	50	25	30	35	35	3.5	3.5	1.5	1.5	100	150
Cass silty clay	Cs	40	65	25	30	35	35	3.5	3.5	1.5	1.5	120	150
Hamburg very fine sandy loam	Hv	----	----	----	----	----	----	----	----	----	----	20	20
Knox silt loam:													
Sloping phase	Kss	20	50	18	25	25	40	1.0	2.5	1.0	1.5	75	125
Sloping light-textured subsoil phase	Ksx	30	60	18	25	25	45	3.0	3.0	1.5	1.5	75	150
Steep light-textured subsoil phase	KsL	----	----	10	25	20	40	1.0	2.5	.75	1.5	50	100
Strongly sloping phase	KsT	----	----	18	25	24	40	1.0	2.5	.5	1.0	75	125
Strongly sloping light-textured subsoil phase	KsR	20	50	18	25	25	45	1.5	3.0	.75	1.5	60	125
Mandeville silt loam:													
Moderately steep phase	MsM	20	40	15	25	25	40	1.0	2.5	.75	1.25	60	100
Sloping phase	Mss	25	50	15	25	25	40	1.0	2.5	.75	1.25	75	125
Marshall silt loam:													
Eroded sloping phase	MLE	25	55	18	30	30	40	1.0	3.0	.75	1.5	75	150
Eroded strongly sloping brown phase	MLD	25	50	18	25	30	40	2.0	3.0	1.0	1.5	60	120
Sloping phase	MLS	40	60	25	35	40	55	3.0	3.5	1.25	1.5	120	170
Sloping brown phase	MLW	40	60	25	35	40	55	3.5	3.5	1.25	1.5	80	40
Undulating phase	MLU	50	70	25	35	40	55	3.0	3.5	1.25	1.5	125	175
Undulating brown phase	MLN	45	65	25	35	40	55	3.5	3.5	1.25	1.5	100	150
McPaul silt loam	Mm	40	70	----	----	----	----	3.0	4.0	----	----	75	150
McPaul very fine sandy loam	Mv	40	60	----	----	----	----	----	----	----	----	100	150

See footnotes at end of table.

Moderately steep land (Shelby soil material)	MtS	30	40	------	------	30	35	2. 0	2. 5	1. 0	1. 5	100	125
Napier silt loam:													
Gently sloping phase	Nsg	50	75	25	30	35	50	3. 0	3. 0	1. 5	1. 5	100	150
Sloping phase	Nss	40	60	25	30	30	50	3. 0	3. 0	1. 5	1. 5	100	150
Riverwash	Rv	------	------	------	------	------	------	------	------	------	------	------	30
Sarpy loamy very fine sand	Sd	25	40	15	20	25	40	2. 0	2. 0	1. 0	1. 0	75	100
Overflow phase	Sdo	([2])	([2])	([2])	([2])	([2])	([2])	([2])	([2])	([2])	([2])	([2])	([2])
Sarpy very fine sandy loam	Sv	45	65	25	35	35	45	3. 0	3. 0	1. 5	2. 0	100	150
Overflow phase	Svo	([2])	([2])	([2])	([2])	([2])	([2])	([2])	([2])	([2])	([2])	([2])	([2])
Sharpsburg silty clay loam:													
Eroded sloping phase	Sse	25	50	18	25	30	40	0	2. 5	. 75	1. 25	70	135
Sloping phase	Sss	35	60	25	30	40	50	1. 0	3. 0	1. 0	1. 5	125	175
Undulating phase	Ssu	45	65	25	30	40	50	1. 5	3. 0	1. 0	1. 5	125	175
Shelby loam:													
Eroded sloping phase	Sle	20	35	12	22	25	35	0	2. 0	. 75	1. 25	40	80
Sloping phase	Sls	35	50	18	25	30	40	1. 0	2. 5	1. 0	1. 5	125	150
Strongly sloping phase	Slt	------	------	15	22	25	35	0	1. 75	. 75	1. 25	80	120
Shelby silt loam:													
Eroded sloping phase	Sbe	20	35	15	22	25	50	0	2. 0	. 75	1. 25	40	80
Sloping phase	Sbs	35	50	18	25	30	50	1. 0	2. 5	1. 0	1. 5	125	150
Steep stony land (Mandeville soil material)	StM	------	------	------	------	------	------	------	------	------	------	------	30
Wabash clay	Wc	25	25	25	25	30	30	2. 0	2. 0	1. 5	1. 5	------	------
Ponded phase	Wcp	([3])	([3])	([3])	([3])	([3])	([3])	([3])	([3])	([3])	([3])	------	------
Wabash silt loam	Ws	45	60	25	30	40	45	3. 0	3. 0	1. 5	1. 5	100	150
Wabash silty clay loam	Wl	40	60	25	25	35	40	2. 5	2. 5	1. 5	1. 5	100	150

[1] Cow-acre-days, used to express the carrying capacity of pasture land, is the product of the number of animal units (mature cow, horse, or steer) carried per acre multiplied by the number of days that the animals can be grazed without injury to pasture; for example, a soil that supports 1 animal unit per acre for 360 days rates 360; a soil supporting 1 animal unit on 2 acres for 180 days rates 90; and a soil supporting 1 animal unit on 4 acres for 100 days rates 25.

[2] Maximum yields on this soil are as high as on soil listed immediately above it but are erratic because of overflows.

[3] Maximum yields are as high as on Wabash clay but are erratic because of poor drainage.

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the Nodaway and Missouri Rivers and other streams. The soils of this group have formed from alluvial material. They range from yellowish brown to dark gray. Most areas of the McPaul soils are subject to overflow, as are also areas of Wabash silt loam and the overflow phase of the Sarpy very fine sandy loam. The Napier soils and Sarpy very fine sandy loam are mostly above overflow. All soils of this medium-textured group are productive and are intensively farmed.

The fine-textured soils, Cass clay and silty clay and Wabash clay and its ponded phase, occur in the broad level Missouri River bottom. They are dark or almost black, with surface soils varying from silty clay loam to clay. The Wabash subsoil is dark-gray plastic clay, whereas the Cass soils are underlain by sandy material at depths of 3 or 4 feet. Large areas of these clay soils occur in the shallow swales and are poorly drained. The soils have high fertility, but their productivity is largely dependent upon drainage conditions.

SOIL PRODUCTIVITY

Estimated acre yields of principal crops are given in table 3 for two levels of management, average and good. In columns A are estimated average acre yields for average management, or that level of management used by the majority of farmers in the county in 1940. At this level essentially no lime and fertilizer were used, but a legume crop was grown once in about 4 years. Use of lime and fertilizer has greatly increased since 1940. The "average" management in 1952 is therefore somewhat better than in 1940, and some yields consequently are somewhat higher than shown in columns A. The improvement in present management over that practiced in 1940 has been mostly on upland soils; average management of most bottom land soils remains essentially as it was in 1940.

In columns B of table 3 are estimated yields under good management, which involves the following:

1. Mineral plant nutrients are added as needed, and a readily available supply of nitrogen is maintained by using commercial nitrogen fertilizer or legumes.
2. Where necessary, erosion damage is controlled by proved cultural practices such as terracing and contour tillage, and by cropping systems that aid in minimizing losses.
3. The use of high-yielding varieties of crops. (This is already common practice in the county for corn, wheat, oats, and other grains, but improved varieties of hay and pasture plants should be used.)
4. Crops are efficiently tilled and harvested. (In this county there is little difference between good and average management insofar as tillage and harvesting practices are concerned.)

SOIL TYPES, PHASES, AND LAND TYPES

The soils and land types of the county, identified by the same symbols as are used on the soil map, are described in the following pages, and their agricultural relations are discussed. Their acreage and proportionate extent are given in table 4. The reader should keep in mind that the statements concerning use and management were correct in 1939, when this survey was made. Some practices of use and management given will need to be modified to bring them up to date.

TABLE 4.—*Approximate acreage and proportionate extent of soils mapped in Holt County, Mo.*

Soil	Acres	Percent
Cass clay	18, 385	6. 3
Cass silty clay	7, 715	2. 6
Hamburg very fine sandy loam	1, 948	. 7
Knox silt loam:		
Sloping phase	222	. 1
Sloping light-textured subsoil phase	2, 151	. 7
Steep light-textured subsoil phase	8, 800	3. 0
Strongly sloping phase	4, 108	1. 4
Strongly sloping light-textured subsoil phase	18, 872	6. 4
Mandeville silt loam:		
Moderately steep phase	4, 078	1. 4
Sloping phase	1, 245	. 4
Marshall silt loam:		
Eroded sloping phase	3, 716	1. 3
Eroded strongly sloping brown phase	8, 683	3. 0
Sloping phase	16, 693	5. 7
Sloping brown phase	10, 734	3. 7
Undulating phase	5, 317	1. 8
Undulating brown phase	8, 452	2. 9
McPaul silt loam	33, 869	11. 4
McPaul very fine sandy loam	5, 428	1. 8
Moderately steep land (Shelby soil material)	1, 618	. 6
Napier silt loam:		
Gently sloping phase	3, 305	1. 1
Sloping phase	1, 668	. 6
Riverwash	6, 154	2. 1
Sarpy loamy very fine sand	2, 232	. 8
Overflow phase	678	. 2
Sarpy very fine sandy loam	17, 770	6. 0
Overflow phase	7, 780	2. 6
Sharpsburg silty clay loam:		
Eroded sloping phase	384	. 1
Sloping phase	13, 429	4. 6
Undulating phase	6, 057	2. 1
Shelby loam:		
Eroded sloping phase	4, 889	1. 7
Sloping phase	12, 115	4. 1
Strongly sloping phase	1, 303	. 4
Shelby silt loam:		
Eroded sloping phase	253	. 1
Sloping phase	2, 568	. 9
Steep stony land (Mandeville soil material)	4, 542	1. 5
Wabash clay	9, 209	3. 1
Ponded phase	24, 351	8. 3
Wabash silt loam	11, 335	3. 9
Wabash silty clay loam	1, 704	. 6
Total	293, 760	100. 0

Cass clay (0–1% slopes) (Cc) This soil, derived from fine-textured alluvium over coarse-textured alluvium of the Missouri River bottom, differs from Wabash soils in being underlain by sand at a shallow depth. The topography is level, and drainage is adequate for most crops. Most of the soil is above all but the highest overflows, yet the greater part of it is at elevations slightly lower than the Sarpy soils and is therefore a little more subject to overflow.

Profile description:

0 to 10 inches, dark grayish-brown to black sandy clay or clay; very plastic when wet but dries to hard granular structure.

10 to 15 inches or more, dark-brown or dark yellowish-brown clay.

15 inches or more to several feet, yellowish-brown loamy fine sand or fine sandy loam.

The heavy surface layers, nearly neutral or slightly acid, vary considerably in thickness and in places may measure more than 3 feet thick. The sandy substratum is calcareous.

Use and management.—Most of this soil is cultivated, a large part of it for wheat. Some alfalfa is grown, but the acreage of corn is small. Corn gives high yields when weather is favorable but is quickly damaged by either excess moisture or drought.

The farms are large, and almost all of the farming is done with heavy power machinery. Wheat is drilled in September and October on land plowed in summer and early fall. The crop is combined. The straw is left on the field, and much of it is burned. No fertilizer is used. Under average management wheat yields 15 to 35 bushels an acre, depending on the season. Most of the land is not fenced, for grain production with a few livestock characterizes the farming in this river bottom.

Cass silty clay (0–1% slopes) (Cs).—Most of this soil occurs in the central part of the Missouri River flood plain. It may have been partly timbered, but all of it is now cleared and in cultivation.

Profile description for cultivated areas:

0 to 10 inches, dark-brown to dark grayish-brown silty clay; plastic when wet but of hard granular structure when dry.

10 to 15 inches or more, dusky-brown or dark yellowish-brown silty clay or clay loam.

15 inches or more to several feet, yellowish-brown loamy fine sand or fine sandy loam.

The entire soil mass is neutral, and it may range to calcareous. There is considerable variation in depth to the sandy substratum, which may be within 10 inches of the surface in some places and 3 or 4 feet below the surface in others.

Use and management.—About 50 percent of this land is now used for wheat, 30 percent for corn, and 20 percent for alfalfa. All these crops do well. The soil is generally better drained and easier to till than Cass clay and is better for growing corn. During extreme drought or wet weather, corn yields are lowered more on this soil than on Sarpy very fine sandy loam.

Hamburg very fine sandy loam (30–50% slopes) (Hv).—This is a light-colored loessal soil on steep bluffs (fig. 6, *A*). The areas—inextensive but conspicuous—occur as a narrow band on the bluff face along the edge of the Missouri River flood plain in the central part of the county. The band is seldom as much as half a mile wide but is several miles long. Most slopes come within the 30- to 50-percent range, but a few areas have slopes greater or less than this.

Most areas are covered with a sparse growth of side-oats grama, a little bluestem, wild legumes, and sumac. Near the boundary between this soil and the Knox soils the more protected areas are partly forested with elm, walnut, wild cherry, crab apple, ash, and bur oak.

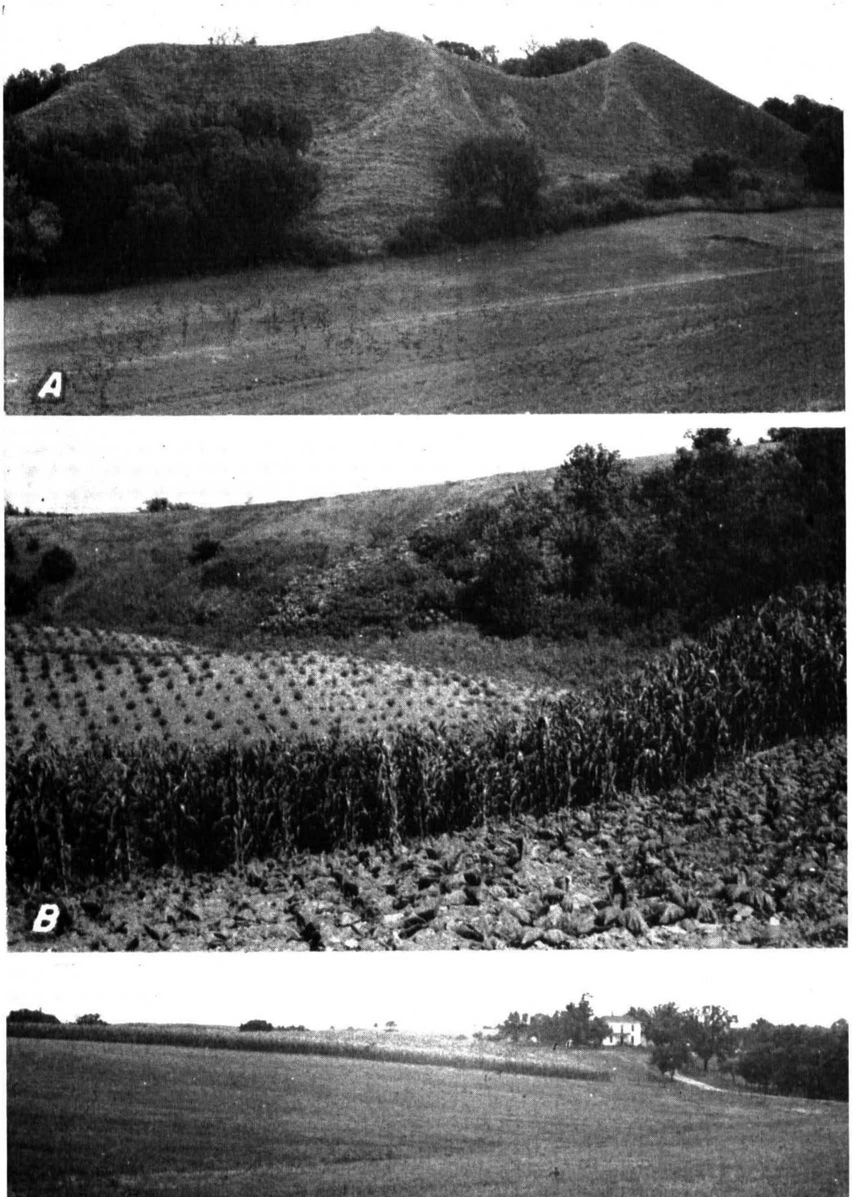

FIGURE 6.—Landscapes in Holt County, Mo.: *A*, Hamburg very fine sandy loam on steep slopes in background and Napier silt loam in sloping valley in foreground. *B*, Tobacco and corn on Knox silt loam, which erodes very rapidly when slopes such as these are cultivated. *C*, Farmstead on Marshall silt loam.

The soil formed from moderately coarse-textured loess that extends to depths of 100 feet or more. The surface 8 to 10 inches is a light yellowish-brown very fine sandy loam or silt loam, smooth and silky to the touch. This part is almost structureless when dry, but a weakly developed fine crumb structure becomes apparent when it is moist. There is no definite subsoil, but below the surface horizon the soil is slightly lighter colored. The gradation from the very fine sandy loam or silt loam surface soil to the light yellowish-brown and pale-brown very fine sandy loam parent material is gradual.

The entire profile is low in organic matter, low in water-holding capacity, and very freely permeable to roots, moisture, and air. It is calcareous throughout and has a few lime concretions at various depths. This soil blends into Knox silt loam soils, and where it borders those soils it may be partly timbered and noncalcareous at the immediate surface.

Use and management.—Hamburg very fine sandy loam is not cultivated; all of it is either in pasture or lies idle. About 10 acres will carry one mature animal through the pasture season.

The steep slopes and loose porous soil and underlying material make this soil highly susceptible to erosion. The organic-matter and nitrogen contents are very low. Water moves through the soil rapidly, and during the summer months plants suffer from lack of moisture.

Knox silt loam, sloping phase (4–12% slopes) (Kss).—This soil has developed from moderately thick loess under forest or a vegetative cover transitional between prairie and forest. It is similar to Knox silt loam, light-textured subsoil phase, in appearance but has a lighter colored surface soil and heavier textured subsoil. Mandeville soils occupy the steeper slopes.

Profile description for areas cultivated but not severely eroded:

0 to 8 inches, light brownish-gray silt loam of weakly developed fine granular structure.

8 to 16 inches, yellowish-brown heavy silt loam; structure particles are hard granules ⅛ to ¼ inch in diameter; material appears lighter colored when structure particles are crushed.

16 to 24 inches, yellowish-brown friable silty clay loam having firm irregularly shaped structure aggregates ¼ to ½ inch in diameter.

24 to 32 inches, yellowish-brown friable silty clay loam with some mottlings of gray and rust brown.

32 to 40 inches, friable silt loam mottled with light yellowish brown and pale brown.

Use and management.—This soil erodes very rapidly under cultivation (fig. 7). It is low in organic matter and has a lime requirement of about 2 tons an acre. If not eroded, it supports bluegrass pasture of fair quality. Some wheat and corn are grown (fig. 6, *B*); and if the land is limed and fertilized, alfalfa and sweetclover can be grown. Crop yields are very low on the badly eroded fields, and bluegrass is difficult to establish on them. Nevertheless, lespedeza and timothy can be grown on the eroded areas.

Knox silt loam, strongly sloping phase (12–20% slopes) (Kst).—This phase has the same profile as the sloping phase but occurs on steeper slopes. Some of it has been farmed and is severely eroded.

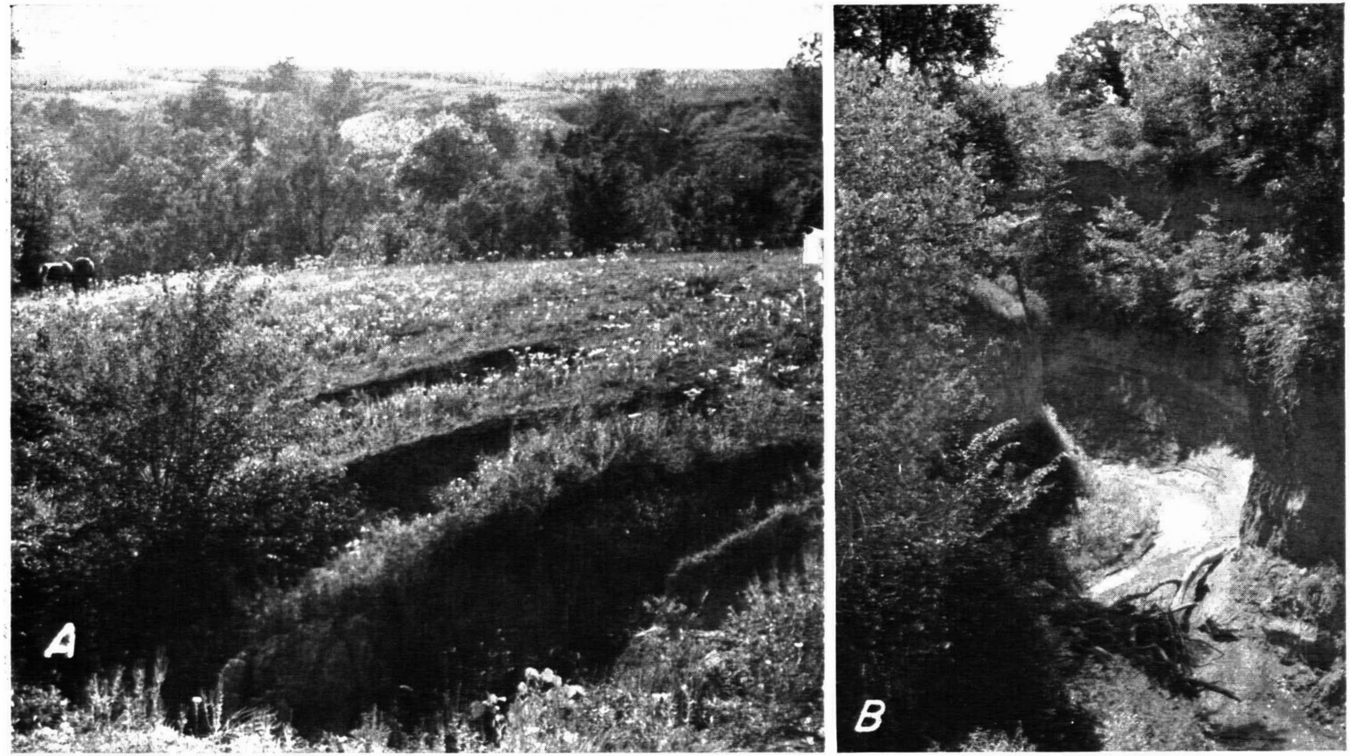

FIGURE 7.—Erosion on Knox silt loam: *A*, Gullies 20 to 30 feet deep, one with a tree growing in it, in foreground. *B*, Steep sided gully following a natural drainageway has cut to a depth of about 50 feet.

Little of it is now being farmed, and if erosion is to be controlled, most of it must be kept under permanent cover. Timothy, lespedeza, redtop, and bromegrass are best suited to this soil.

Knox silt loam, sloping light-textured subsoil phase (4–9% slopes) (Ksx).—This soil has developed under a mixed grass-hardwood forest growth from a deposit of loess more than 20 feet thick. It occurs mainly on narrow ridges with slopes of 5 to 8 percent and was originally partially covered with mixed hardwood trees—black walnut, ash, oak, and elm. Most of it is now cleared of timber.

Profile description of a single area:

0 to 9 inches, brown friable silt loam with a well-developed crumb structure.

9 to 15 inches, yellowish-brown friable silt loam; structure particles easily crushed granules ⅛ to ¼ inch in diameter; material appears lighter colored when granules are crushed.

15 to 30 inches, yellowish-brown friable heavy silt loam with a weak fine subangular blocky structure.

30 inches +, very friable silt loam spotted with yellowish brown and gray; very uniform in appearance to a depth of as much as 40 feet; vertical cuts remain standing for years without slumping.

The surface soil of the profile just described is very slightly acid, but below 3 to 5 feet the material is neutral. The characteristics of this phase, however, are those of slightly weathered soil material, and over much of the area there is almost no profile development. The soil material is mostly of silt and very fine sand, high in mineral nutrients, and of a structure favoring root penetration. In a few widely scattered spots the surface soil is slightly calcareous.

Analyses show that the subsoil is heavier textured than the surface soil but that it is still a silt loam. Data for pH and percentage base saturation indicate that the soil is well supplied with lime and probably with phosphorus and potash. The supply of organic matter and nitrogen is low. The organic matter of Knox soils is concentrated in the surface 6 inches, which explains why they are usually low in organic matter and nitrogen when eroded.

Use and management.—This soil is fertile and easily tilled and can be farmed without serious erosion damage. The principal limitation to use is its position, for it occurs on narrow crooked ridge tops, mostly in areas of a size and shape difficult to use separately.

Corn is the principal crop, but some tobacco is grown, as well as alfalfa, sweetclover, and red clover. Tomatoes are grown on a commercial scale but not on a large acreage.

Wherever possible, the ridge tops should be used separately from the slopes. The ridge can be cropped without serious erosion damage; the slopes cannot. Alfalfa and clovers can be grown without soil treatment, and the acreage of these legumes should be increased. Corn should be grown only where it follows a legume or grass.

Knox silt loam, strongly sloping light-textured subsoil phase (9–19% slopes) (Ksr).—Most of the surface soil has been eroded from this phase. Where it is not eroded it is similar to the Knox soils on ridge tops, but in general it has a subsoil slightly lighter in color and lighter in texture. Between Mound City and Oregon there are many places on the eroded hillsides where the soil is calcareous at the surface.

Use and management.—Most of this soil, the most extensive phase of Knox silt loam, has been farmed at some time. In addition to having lost most of its surface soil, some fields of it are dissected by gullies that have cut down deep into the loose friable loess. Because the soil has steep slopes and is loose and friable, erosion control will always be a difficult and constant problem. Terracing, contour cultivation, and strip cropping will aid in slowing down erosion. Slopes bare of vegetation erode much more rapidly than those covered, and therefore a type of farming that keeps the surface covered most, or all, of the year is preferable to one leaving the land bare for long periods. Maintenance of organic matter and nitrogen are also major problems on this soil. Once established, legumes can supply their own nitrogen, and most of them leave some surplus in the soil. If nonlegume crops such as corn are to be grown successfully, nitrogen in some form must be added. Alfalfa and sweetclover can be grown without fertilizer treatment. An alfalfa-timothy or alfalfa-bromegrass mixture makes a good meadow and furnishes enough cover to control erosion on most slopes.

Keeping of more dairy cattle would be desirable for this soil, as abundant legume hay can be produced and supplemental pasture crops of high carrying capacity can be grown. A decided drawback to livestock farming is lack, in some sections, of an adequate water supply.

Most farms on this soil and others of its series depend on shallow wells or cisterns. During prolonged drought both the cisterns and shallow-vein wells may go dry, and water has to be hauled, sometimes for a distance of several miles. This light-textured subsoil phase is too porous for successful use of ordinary farm ponds. Earth dams have been used in various places to check gullies.

Knox silt loam, steep light-textured subsoil phase (19–30% slopes) (KsL).—Except for its location on steep hillsides, this soil is similar to other light-textured Knox soils previously described. All of it that has been farmed is badly eroded, and a calcareous surface soil is fairly common where erosion has occurred. A permanent plant cover must be kept on the soil if erosion is to be controlled. Some areas must be reforested if the soil is to be stabilized. Overgrazing must be avoided.

Mandeville silt loam, sloping phase (7–12% slopes) (Mss).—This light-colored soil derived from Coal Measure limestone and shale is associated with Steep stony land (Mandeville soil material) and the Knox soils in the southeastern part of the county. It occurs mostly as strips or bands around the heads of drainageways—between areas of Knox silt loam on the ridge tops and Steep stony land (Mandeville soil material) on the steeper slopes. Few continuous areas are more than 100 acres in size. The original cover was oak-hickory forest, but most of the land is now cleared.

Profile description:

0 to 10 inches, light brownish-gray or pale-brown very friable silt loam.

10 to 18 inches, yellowish-brown heavy silt loam of well-developed coarse granular structure; structure particles uniform in size and about one-eighth inch in diameter.

18 to 26 inches, brown to yellowish-red silty clay loam; plastic when wet but breaks into hard irregularly shaped aggregates when dry.

26 to 36 inches, brown silty clay loam containing spots of reddish brown and yellowish red; variable in thickness; grades into partly decomposed shale and limestone at depths of 24 to 40 inches.

The upper 26 inches is slightly acid, but below this depth the soil is in most places neutral or calcareous. Limestone fragments are scattered throughout the soil mass.

This is one of the most variable soils in the county. Locally its surface soil may be dark brown, and a few feet away, a light brownish gray. Probably the surface layers contain appreciable quantities of loess. On some of the lower slopes of steep rocky hills near Forbes this soil includes areas too small to map separately that appear to be almost entirely loess throughout the upper 3 feet of their profile.

Use and management.—This soil is less productive than Knox silt loam on comparable slopes. About half of it is in pasture. The rest is in corn, small grains, and a small total acreage of red clover. Crop yields are medium to low.

Many of the cultivated fields appear yellowish brown because the surface soil has been washed away and the subsoil exposed. Meadow or pasture is the most suitable use for this soil.

Mandeville silt loam, moderately steep phase (12–20% slopes) (Msm).—In profile characteristics this soil is essentially the same as Mandeville silt loam, sloping phase. Most of it is in pasture. Some areas have been farmed and are now severely eroded; other areas are in timber. This soil is best suited to pasture, but some of the less steeply sloping areas can be used for hay or rotations of small grains and hay.

Marshall silt loam, undulating phase (2–6% slopes) (Mlu).—This dark-brown Prairie soil occupies rounded ridge tops (fig. 6, *C*) and has good surface drainage. The open friable subsoil insures adequate internal drainage. The parent material is similar to that of the Knox soils. Soils of both series have developed from loess, but that under this and other Marshall soils has a maximum thickness of about 15 feet. Deep cuts in the loess of this and other Marshall soils do not stand vertically as do those nearer the bluff but instead slump to an angle of about 70 degrees. In sections where both Marshall and Shelby soils occur, the Marshall soils mantle the ridge tops and the Shelby soils occupy the steeper slopes.

Profile description:

0 to 12 inches, dark-brown mellow silt loam with a well-developed fine granular or crumb structure.

12 to 18 inches, moderate-brown to dark-brown friable silt loam; structure particles larger than in the immediate surface layer and slightly more firm.

18 to 32 inches, yellowish-brown firm silty clay loam; structure particles larger and firmer than in the surface layer.

32 to 40 inches, light yellowish-brown heavy silt loam in which may occur a few flecks of reddish brown.

40 inches +, light yellowish-brown and pale-brown silt loam.

The principal profile variations are caused by differences in slope and in erosion. Generally this soil is on ridge tops and has a slightly thicker surface soil than Marshall silt loam, sloping phase. Tests indicate that the soil is slightly acid, but alfalfa and all types of clover are grown without adding lime.

Use and management.—Because this phase is on ridge tops it is less subject to erosion than other phases of Marshall silt loam on surrounding slopes. Nevertheless, it is seldom used separately. The ridge tops and the slopes if not badly eroded are usually farmed together. This soil should be farmed separately to the greatest extent feasible, for it can be safely used more intensively than the sloping phases.

In practice this undulating phase is farmed in much the same way as the sloping phases. The following discussion of management therefore applies to this phase and the sloping phases.

About 35 percent of the combined area of the undulating and sloping phases of Marshall silt loam is used for corn. Permanent pasture occupies 15 to 20 percent; annual pasture crops about 10 percent; and wheat, oats, alfalfa, and red clover and sweetclover the rest. Bluegrass makes vigorous growth, and well managed pastures furnish 175 cow-acre-days of grazing annually. Bluegrass fields stripped for seed yield 400 to 600 pounds of uncleaned seed an acre.

Most of the corn is planted with a lister. A small but increasing percentage of the corn is listed on the contour. Land to be sown to wheat is usually plowed during summer and the wheat drilled about the last of September.

Few fields are cropped in a regular rotation. Most of them are used for corn 2 years in succession and then sown to oats-and-legume meadow for 2 years or more. Many fields, however, have been cultivated 10 years or more without growing any legume crops.

The effect of growing corn continuously on Marshall soils without soil treatment is shown by a decline in yields. Erosion is also much more rapid on the sloping land used for continuous corn than on land used in a rotation containing 1 year or more of meadow. Experiments on a 9 percent slope on Marshall silt loam at the Soil Conservation Service Experiment Station, Clarinda, Iowa, for the period 1933–42 indicate that the average soil loss is about twice as great for corn grown continuously as for corn grown in a rotation of corn, oats, and clover.[3] The average yield for continuous corn was 28.5 bushels an acre, whereas corn grown in rotation produced an average yield of 42.9 bushels. The decreased corn yield under continuous corn appears to result principally from decreased organic matter, unfavorable soil structure, and lack of available nitrogen.

Contour listing is effective in decreasing runoff and erosion on Marshall soils. At the Clarinda station, fields listed on the contour from 1933 to 1940 lost only about a fifth as much soil as those listed up and down the slope. Runoff was also reduced in about the same proportion. Contour listing results in slightly higher long-time average yields of corn on the Marshall soils.

Terraces are also effective in reducing erosion losses on Marshall soils, but, even when all known practices are followed, some erosion will occur on the sloping areas. As on the Knox soils, erosion control on the more rolling Marshall soils is a difficult and never-ending task.

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[3] Browning, G. M., Norton, R. A., McCall, A. G., and others. INVESTIGATION IN EROSION CONTROL AND THE RECLAMATION OF ERODED LAND AT THE MISSOURI VALLEY LOESS CONSERVATION EXPERIMENT STATION, CLARINDA, IOWA, 1931–42. U. S. Dept. Agr. Tech. Bul. 959, 88 pp., illus. 1948.

By taking advantage of mechanical practices, such as terracing and contour listing, and by maintaining vigorous stands of vegetation as much of the time as possible, erosion can be reduced to the point where it will not be a serious threat to continued productivity of the soils.

Marshall silt loam, sloping phase (6–8% slopes) (Mls).—Slopes adjacent to the undulating phase of Marshall silt loam are occupied by this soil. The profile except for being slightly shallower, is essentially the same as for the undulating phase.

Use and management.—The problems of use and management are those already discussed for Marshall silt loam, undulating phase. This phase is used in essentially the same way as the undulating phase. though it should not be used so frequently for row crops. The soil should be terraced and farmed on the contour if it is to remain productive under cultivation.

Marshall silt loam, eroded sloping phase (8–13% slopes) (Mle).—Most of the surface soil has been eroded from this phase, but aside from this difference the profile is essentially the same as that of Marshall silt loam, undulating phase. A slope of about 8 percent appears critical for the Marshall silt loam soils. Slopes of less than 8 percent apparently can be farmed without serious erosion damage, but when those steeper than 8 percent are farmed erosion is very severe. If steeper slopes such as those of this phase are to remain in cultivation, cropping sequences different from those used in the past must be practiced. The effects of some erosion control practices on crop yields, water loss, and soil loss are discussed under the heading Use and Management in the description of Marshall silt loam, undulating phase.

Crop yields, especially of corn, are lower on this eroded soil than on the undulating phase. This soil is low in organic matter but high in mineral plant nutrients and with careful treatment can be made productive. Small grains, grasses, and legumes for pasture or hay should be the principal crops. Before nonlegume crops can be successfully grown, nitrogen in some form should be added to this soil.

Marshall silt loam, undulating brown phase (3–7% slopes) (Mln).—This is one of three brown phases of Marshall silt loam occurring as a belt between the phases of Marshall silt loam already described and the Knox soils. These brown phases cover nearly all of the upland in the region where they occur, but there are a few areas near Mound City where Shelby soils occur with them. In contrast, within the areas occupied by the other[4] phases of Marshall silt loam occur a considerable percentage of Shelby soils. The general position of the brown phases is on ridges and slopes. They occur in a strip between the Knox soils and the other phases of the Marshall soils.

The brown phases have dark surface soil similar to that of Marshall silt loam already described and an open friable subsoil similar to that of the light-textured subsoil phases of Knox silt loam. The following profile description of Marshall silt loam, undulating brown phase, except for differences subsequently mentioned, is representative of all the brown phases of Marshall silt loam.

[4] For ease of comparison the term "other" is used to designate the undulating, sloping, and eroded sloping phases of Marshall silt loam. This term, of course, is not a part of the names for these soils.

0 to 12 inches, dark-brown very friable silt loam with a well-developed fine granular structure.

12 to 18 inches, dark-brown friable silt loam; weak fine subangular blocky structure; material dark yellowish-brown when aggregates are crushed.

18 to 28 inches, brown friable heavy silt loam of weak medium subangular blocky structure.

28 to 36 inches, brown to yellowish-brown friable silt loam of massive structure.

36 inches +, light yellowish-brown very friable silt loam.

Cuts 10 to 20 feet deep in this soil material will stand with vertical side walls for many years without slumping. The surface soil is essentially the same as that for the other phases of Marshall silt loam, but the subsoil is slightly less developed. The brown phases of Marshall silt loam formed from loess a little coarser textured and slightly deeper than the deposit from which the other Marshall silt loam soils have developed. The pH of the surface soil is usually slightly below 7 (slightly acid) for the brown phases, but alfalfa, red clover, and sweetclover are grown without adding lime. For the brown phases, the pH of the surface soil ranges from 6.2 to 6.5; the subsoil, from 6.3 to 6.7.

Boundaries between Knox soils and the brown phases are based on differences in surface color, which are usually fairly distinct. The brown phases blend into the other phases of Marshall silt loam, however, and near its boundaries any particular soil area may have some characteristics of both the brown and other phases.

Use and management.—The undulating brown phase of Marshall silt loam is less subject to erosion than the sloping brown phase and has somewhat different management problems. It occurs in small irregularly shaped areas on ridge tops, however, and is therefore usually farmed in the same way as the surrounding slopes. This brown undulating phase is similar to the undulating phase of Marshall silt loam in crop adaptations, productivity, and soil management problems. It is slightly better for alfalfa and sweetclover but not so good for bluegrass. Not more than 10 percent of the undulating brown phase is in permanent pasture; the rest is in corn, wheat, oats, alfalfa, red clover, and sweetclover. Yields are about the same as on the undulating phase of Marshall silt loam. Aside from using manure and growing legumes, very little soil treatment has been practiced.

Marshall silt loam, sloping brown phase (7–10% slopes) (MLW).—This soil occurs on hillside slopes in the same general region as the undulating brown phase and has essentially the same profile. Crop adaptations, productivity, soil management problems, and the crops grown are essentially the same as for the undulating brown phase, but erosion control is more difficult. All clean-tilled crops should be planted on the contour, and fields used for cultivated crops should be terraced. (For a discussion of terraces read under the heading Use and Management in the description of Marshall silt loam, undulating phase, pp. 27 and 28.) Included with this sloping brown phase are areas with occasional deep steep-sides gullies.

Marshall silt loam, eroded strongly sloping brown phase (8–15% slopes) (MLD).—Steeper hillsides are occupied by this soil. Erosion has removed most of the surface soil, and freshly plowed fields therefore appear yellowish brown. The yellowish-brown subsoil now ex-

posed is medium-textured and high in mineral nutrients but low in supplies of organic matter and nitrogen. It is very difficult to prevent further erosion if this soil is used for corn or other clean-tilled crops. Yields of corn are low because the soil is low in content of nitrogen. This phase can be used for clover, alfalfa, and grass.

McPaul silt loam (0–4% slopes) (Mm).—This soil consists of silty material washed from Knox and Marshall (upland) soils and deposited over river-bottom soils. The surface soil (deposited material) is mellow fine granular brown silt loam, which varies from 10 inches to several feet thick over the buried soil. The deposition is taking place very rapidly. There are about 53 square miles of the soil in this county, and practically all the deposition has taken place since the land was settled—most of it in the past 50 years. Recent studies indicate that the McPaul soil area is increasing about one-half square mile a year. The soil lies in the Missouri River bottom, mostly in the area formerly known as Impassable Lake. Extensive areas occur along the Little Tarkio Creek drainage ditch north of Bigelow and along the Kinsey Creek and Squaw Creek ditches in the central part of the county.

Drainage is generally good because artificial drainage has been constructed for some areas. Unless protected by levees, most areas are flooded by hill streams after heavy rains. Many fields have been built up by using diversion ditches and dikes. Floodwaters laden with silt are directed through diversion ditches and allowed to spread over a leveed field. The floodwater is kept on the field until the silt settles out and is then drained away. In this way several inches of silt are sometimes deposited after a single rain. As soon as an area has received the desired amount of silt, dikes are erected to protect it from subsequent floods, and the water is diverted to other areas.

A 2,200-acre settling basin along the Little Tarkio Creek drainage ditch is silting very rapidly. The primary purposes of this basin are to prevent silting of the Little Tarkio Creek channel and to cover the heavy poorly drained soil within the basin with sediment having desirable physical properties.

Included with McPaul silt loam in mapping are light-colored recent deposits along smaller streams. These have surface layers essentially the same as those in the Missouri River bottom, but the underlying material (the buried soil) is usually a silt loam rather than a clay. Most of these areas along small streams are flooded annually and in some years may be flooded several times. The floods, however, are of short duration and usually do not cause severe damage.

These inclusions are associated with Wabash silt loam, and because deposition is taking place rapidly, the acreage of these soils is increasing and that of Wabash silt loam is decreasing. If deposition continues at the present rate it is probable that Wabash silt loam eventually will be covered with light-colored sediments.

Use and management.—Most of McPaul silt loam in the Missouri River bottom is cultivated. Corn, the main crop, continues to grow during droughts severe enough to damage the crop on upland soils (fig. 8). Corn yields 40 to 70 bushels an acre, and yields of 80 bushels or more are not uncommon. The included areas along small streams are used for corn where they are not too small or too dissected by drainage channels. Those areas not cultivated are used for pasture. Bluegrass makes good growth.

FIGURE 8.—Crops on McPaul silt loam: *A*, Lespedeza in foreground and corn in middle distance. *B*, Corn that has received no rain since the first cultivation (estimated yield, 80 bushels an acre).

McPaul very fine sandy loam (0–2% slopes) (Mv).—This alluvial soil occurring along the Nodaway River has a dull-brown to brownish-gray mellow very fine sandy loam surface soil. At any depth below 4 to 6 inches thin beds and lenses of coarser or finer material may occur. In places this soil has been deposited on Wabash soils, and where this has occurred the dark-brown silt loam, silty clay loam, or clay loam of the Wabash soils may be at depths ranging from 18 inches to several feet. The brown silty alluvial material is slightly acid.

Use and management.—From 50 to 75 percent of this type is cultivated. Corn, the principal crop, produces good yields when not damaged by floods. Flooding is generally considerably less in the northern part of the valley than the southern because the Nodaway River channel has been straightened above New Point but is crooked below. Floodwaters flow down the straightened channel so rapidly that the crooked channel below cannot carry them, and consequently the lower part of the valley is flooded.

Moderately steep land (Shelby soil material) (7–19% slopes) (MtS).—This land type has developed on a bench of glacial material that outcrops below the Knox and Hamburg soils along the edge of the Missouri River bluffs. The areas are discontinuous and usually less than an eighth of a mile wide. These areas are mostly from glacial clay, but in some places loess has slumped down over the clay. The profile characteristic of most areas is as follows:

0 to 10 inches, brown or dark-brown silt loam or loam.

10 to 18 inches, grayish-brown or brown clay loam containing some glacial pebbles.

18 to 30 inches, yellowish-brown clay loam containing glacial pebbles and lime concretions.

30 inches +, gray-and-brown mottled friable calcareous sandy clay; differs from parent material of other Shelby soils in being more uniformly calcareous and in having many pockets of sand or gravel.

The surface soil ranges from slightly acid to calcareous; the subsoil is calcareous.

Use and management.—This land originally had a mixed cover of timber and prairie grasses. Most of the area has steep slopes and is used for pasture. Gently sloping areas are cultivated.

Napier silt loam, gently sloping phase (1–7% slopes) (NsG).—The profile of this dark-colored soil is similar to that of the Marshall soils. It has developed on alluvial fans and low slopes in coves at the edge of the bluffs. Nearly all of the land is above overflow.

Profile description:

0 to 8 inches, dark-brown mellow fine granular silt loam.

8 to 16 inches, dark-brown friable silt loam with larger and firmer structure particles than in layer above.

16 to 24 inches, moderately dark-brown medium granular mellow silt loam.

24 to 36 inches, brown coarse granular heavy silt loam.

36 inches +, yellowish-brown friable silt loam.

The surface soil is slightly acid to calcareous; the subsoil, calcareous in most places.

Use and management.—Most of this highly productive soil is cultivated. Corn, alfalfa, wheat, clovers, and tobacco are grown.

Napier silt loam, sloping phase (7–15% slopes) (Nss).—This soil occurs in high sloping valleys or terrace positions in the region of

Knox and Hamburg soils. It has formed from colluvial loessal material derived from higher surrounding uplands and occupies the same position in the small valleys that the gently sloping phase of Napier silt loam occupies in the Missouri River valley. Included in mapping because of their small extent are some areas having a dominant slope range of 3 to 7 percent.

This phase lies above overflow, though along some of the streams it occupies all of the valley floor. In these valleys the streams have cut down from 10 to 40 feet through loose friable material and formed a narrow steep-sided gorge. Erosion is variable. Some small areas are eroding rapidly, and others are receiving deposits from the surrounding hills.

Profile description:

0 to 10 inches, dark-brown very friable fine granular silt loam.

10 to 18 inches, weak-brown friable silt loam; structure particles larger and firmer than in surface layer.

18 to 30 inches, brown or yellowish-brown heavy silt loam with a well-developed coarse granular structure.

30 inches +, yellowish-brown friable silt loam.

The entire profile is neutral to calcareous.

Use and management.—Most of this phase is cultivated. It is used for corn, alfalfa, and grass, and yields are high. Fields are frequently small and irregularly shaped.

Riverwash (0–2% slopes) (Rv).—This land type consists of very recent deposits along the Missouri River that lie at such low elevation that they are flooded when the river is high. All textures from coarse sand to clay are represented, but the sand predominates. None of the land is farmed, but some areas are pastured. Much of it is covered with willows.

Sarpy loamy very fine sand (0–2% slopes) (SD).—The surface soil is light yellowish-brown loamy very fine sand to fine sand. There is no consistent change in the soil to a depth of several feet, but lenses of heavier material may occur at any depth. The soil is high in lime and moderately high in mineral nutrients. Its sandy and loose texture allows rapid percolation of water. The surface is hummocky, with variations of 2 to 3 feet.

Use and management.—Most of this soil is cultivated. Truck crops, small grains, sweet clover, and alfalfa are grown. Melons make good growth. Corn responds very well to such green-manure crops as sweetclover.

Sarpy loamy very fine sand, overflow phase (0–2% slopes) (SDO).—Small areas of this soil occur at the heads of bars and islands along the Missouri River. The soil is the same as Sarpy loamy very fine sand on the higher bottom lands, but it is subject to frequent overflow and deposition of new sediments. Most of this phase is idle.

Sarpy very fine sandy loam (0–2% slopes) (Sv).—This is the most extensive soil of the Sarpy series in the county. Its 14- to 24-inch surface layer is grayish-brown or yellowish-brown mellow very fine sandy loam. It is slightly lighter in color in the lower part. Beneath this medium-textured layer there is usually a coarser textured substratum of loamy fine sand or fine sand. The profile is neutral to calcareous throughout. There are minor variations in texture and

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depth of the surface layer—from silt loam to fine sandy loam in texture and from 10 inches to several feet in depth.

Most of this soil lies above all but the highest overflows. This soil, as is true also for Sarpy loamy very fine sand, is usually at higher elevation than the heavier Cass and Wabash soils.

Use and management.—Almost all of this soil is cultivated. Corn, alfalfa, clover, and wheat are grown, and yields are high. No soil treatments are used.

Sarpy very fine sandy loam, overflow phase (0–2% slopes) (Svo).—Several square miles of this soil occupies more recently formed bars and islands along the Missouri River. The soil is essentially the same as Sarpy very fine sandy loam but occupies lower positions and is subject to more frequent overflow. Some areas receive additional sediment from floods.

Use and management.—Fertility is high, and about half of the soil is now cultivated, mostly to corn. Some wheat and alfalfa are grown. The land not cultivated, mostly covered with willows and cottonwoods of various ages, is used for pasture or is idle.

Sharpsburg silty clay loam, undulating phase (1–6% slopes) (Ssu).—This is one of three phases of Sharpsburg silty clay loam occuring in the county, and the following applies to all three: The soils are similar to Marshall soils but heavier textured in surface soil and subsoil. The loess from which the Sharpsburg soils formed is finer textured and not so thick as that under the Marshall. The following profile description for the undulating phase of Sharpsburg silty clay loam is representative for the other two phases:

0 to 10 inches, dark-brown friable silty clay loam with a well-developed granular structure.

10 to 16 inches, brown silty clay loam with a firm granular structure.

16 to 24 inches, dull brownish-gray heavy silty clay loam with some streaks and spots of lighter brown; sticky and plastic when wet but breaks into small irregularly shaped fragments on drying.

24 to 38 inches, yellowish-brown silty clay loam with a weakly developed coarse blocky structure; some dark stains are on surfaces of the soil aggregates.

38 inches +, yellowish-brown and gray mottled heavy silt loam; iron stains may be present to a depth of several feet.

Use and management.—The undulating phase of Sharpsburg silty clay loam occurs on rounded ridge tops generally wider than those in Marshall soil regions, but it is usually farmed with the sloping and eroded sloping phases of Sharpsburg silty clay loam. The discussion of management in the following paragraphs therefore applies to all three phases.

About 30 percent of the ridges in the Sharpsburg soil area are in bluegrass, which is used for both pasture and seed. Excellent stands of bluegrass are maintained. The cultivated land is used for corn, oats, wheat, red clover, and alfalfa. Legumes do better when lime is applied.

Bluegrass thrives on Sharpsburg soils, and a large percentage of their area is used for this crop. Seed is produced in large quantities.

The Sharpsburg soils contain more clay, are less affected by dry weather, and are therefore better adapted to bluegrass than the more open and permeable Marshall soils. Livestock are raised and fed for market in large numbers.

Sharpsburg silty clay loam, sloping phase (6–9% slopes) (Sss).—The profile of this soil is essentially the same as that described for the undulating phase, and, though slopes are steeper, agricultural use is practically the same. This and other phases of Sharpsburg silty clay loam usually occupy gentle upper slopes; the Shelby soils may occur on the steeper lower slopes.

Sharpsburg silty clay loam, eroded sloping phase (6–9% slopes) (SsE).—Most of the dark-colored surface soil has been eroded from this phase. The present surface soil is yellowish-brown somewhat sticky silty clay loam. Aside from this, the profile is essentially the same as that of the undulating phase. This eroded soil is more difficult to plow and is less productive, particularly of corn, than the eroded phases of the Marshall soils. Sweetclover and red clover can be grown with fair success if the land is limed. Lespedeza and lespedeza-grass mixtures can be grown without special soil treatments.

Shelby loam, sloping phase (5–12% slopes) (SLs).—This and the other phases of Shelby loam occur extensively in the northern part of the county. These Shelby soils occupy steeper slopes; Marshall soils mantle the ridges. The Shelby soils developed under prairie vegetation, but sumac, hazel, and hawthorn occur in places, and near streams elm, hickory, and oak have invaded the prairie. Big bluestem and little bluestem were the dominant grasses.

The soils were derived from glacial till—a sandy clay containing small quantities of gravel—that ranges from a few feet to about 50 feet thick. In places lime has accumulated in the form of concretions. The glacial deposit rests on residual limestone and shale similar to those from which Mandeville soils are formed.

The sloping phase of Shelby loam, representative of the other phases mapped, has a dark surface soil, a moderately developed subsoil, and contains sand and gravel throughout. Its profile is described as follows:

0 to 10 inches, dark-brown very friable loam with a well-developed fine granular structure; may contain a few small pebbles.

10 to 15 inches, brown friable clay loam with a well-developed fine blocky structure.

15 to 24 inches, brown or yellowish brown clay loam; plastic when wet but breaks into small hard irregularly shaped aggregates when dry.

24 to 48 inches, light yellowish-brown clay loam mottled with various shades of brown and gray.

48 inches +, yellowish-brown clay loam mottled with various shades of brown and gray; lime concretions—small soft round white pebbles—are usually present.

Pebbles are present throughout the entire soil but usually more numerous below 20 inches. The depth to lime concretions is variable, and in places there may be none to a depth of several feet. The soil is medium acid to the depth at which the lime concretions occur.

Use and management.—An introductory statement concerning Shelby soils as a group is necessary to an understanding of use and management for this sloping phase and other Shelby phases yet to be described:

When the region of dark prairie soils in this county was first farmed, about 60 to 70 years ago, all the soils were considered about equally productive. Much of the land in this prairie area was plowed and planted to corn, and large yields were obtained. The combina-

tion of steep slopes, loose mellow surface soil, and cultivation encouraged rapid erosion. Within a generation much of the land in the dark prairie soil area had lost much of its topsoil. Erosion was more apparent on the Shelby soils than the Marshall because of the higher clay content in the subsoil of the former.

Erosion damage is more serious on the Shelby soil than on the Marshall. On Marshall soils the subsoil can be kept at a relatively high level of productivity by adding fertilizer and organic matter. In contrast, the Shelby subsoil is difficult to get into good tilth, even after fertilizer and organic matter are added. A considerable part of the Shelby loam area has already been removed from cultivation because of erosion, and the acreage will increase unless erosion is checked.

About half of the Shelby loam area is now in permanent pasture, the quality of which varies widely according to degree of erosion. Some very good bluegrass pastures are found on uneroded areas. In contrast, there is a very poor growth where the surface soil is thin. The land cultivated is used for corn, oats, wheat, lespedeza, and red clover. Alfalfa and sweetclover also can be grown if lime is used.

The effect of various cropping systems on Shelby loam in this county can be judged from data on runoff and erosion obtained by the Soil Conservation Service Experiment Station on a similar soil at Bethany, Mo. These data, presented in table 5, show that any cropping system that leaves the soil bare much of the year allows rapid erosion, whereas a bluegrass sod is very effective in preventing erosion. Land in corn erodes rapidly under ordinary systems of tillage. Experiments at the Bethany station show that if a field is planted on the contour the loss is half as much as if it is planted up and down the slope.

TABLE 5.—*Runoff and erosion from Shelby loam under various cropping systems* [1] *and a rainfall of 30.26 inches*

[All plots 72.6 feet long and on 8-percent slopes]

Crop or treatment	Runoff		Soil lost in runoff	Time to erode 7 inches of soil [2]
	Inches	*Percent*	*Tons per acre*	*Years*
Corn	8.20	27.10	50.93	20
Corn-wheat-meadow-meadow rotation [3]	4.90	16.20	9.06	110
Alfalfa	2.04	6.74	.15	6,700
Bluegrass	2.45	8.10	.16	6,300
Fallow on area with original surface soil	8.74	28.88	81.22	12
Fallow on area with subsurface soil exposed	8.68	28.68	56.51	18

[1] Smith, D. D., and others. TEN YEARS OF SOIL CONSERVATION INVESTIGATION ON THE SHELBY LOAM AND ASSOCIATED SOILS. Soil Conservation Service Experiment Station, Bethany, Mo., June 1941. [Processed.]

[2] Based on assumption that the weight of an acre of surface soil to a depth of 7 inches is 2 million pounds.

[3] Figures given are averages for the entire rotation.

In table 6 are presented data obtained by the Bethany Experiment Station that show how yields are affected where Shelby loam has lost its original surface soil through erosion. These data show that low yields must be expected if the soil is not treated and that, even under the best of management, yields will be so low as to make desurfaced Shelby loam marginal for corn production. Briefly then, treatment of Shelby loam that has lost its original surface soil will increase production, but yields will still be lower than on normal (uneroded) Shelby loam.

Terraces have been used effectively on Shelby loam at the Bethany station. Two fields cropped to a rotation of corn, oats, and meadow were used for comparison—the one unterraced and farmed with the field boundaries, the other terraced and farmed on the contour. Over a 5-year period soil loss and water loss, as measured at the terrace outlet, have been 2.7 and 71 percent less, respectively, on a terraced field than on an unterraced field.[5]

TABLE 6.—*Crop yields from normal and desurfaced Shelby loam with and without treatment for 12-year period 1931–42* [1]

Treatment	Crop	Yield per acre	
		Normal soil	Desurfaced soil
None	Corn [2] ... bushels	14. 3	6. 8
	Oats ... do	23. 2	5. 9
	First-year meadow ... tons	. 75	. 5
Lime; 188 pounds 20 percent phosphate an acre on oats; 8 tons an acre manure and a sweetclover cover crop plowed under before corn; cornstalks removed.	Corn ... bushels	37. 3	17. 3
	Oats ... do	46. 9	25. 7
	Meadow ... tons	1. 46	(3)

[1] See footnote 5 at bottom of this page.
[2] Yields lower than average because drought and insects destroyed crop in 1934 and 1936.
[3] Plowed under.

A general statement about water supplies will apply to all the Shelby soils. The supply is adequate except during periods of extreme drought. Farm ponds are used for stock water, and more of them probably could be used to advantage. Cisterns store water for household use, and vein wells are located along the small streams. The shallow wells are in alluvial material and the glacial clay. Deeper wells are drilled to water in sand pockets in the glacial till or running at the point of contact between the glacial clay and country rock.

Shelby loam, eroded sloping phase (6–12% slopes) (SLE).—Erosion has removed almost all the original dark-brown loam surface

[5] SMITH, D. D., WHITT, D. M., ZINGG, A. W., and others. INVESTIGATION IN EROSION CONTROL AND RECLAMATION OF ERODED SHELBY AND RELATED SOILS AT THE CONSERVATION EXPERIMENT STATION, BETHANY, MISSOURI, 1930–42. U. S. Dept. Agr. Tech. Bul. 883, 175 pp., illus. 1945.

soil from this phase and exposed the yellowish-brown clay loam subsoil, which is low in organic matter and high enough in clay content to be difficult to till. Except for loss of original surface soil, the profile is the same as that described for the sloping phase of Shelby loam. The use and management of this and other eroded Shelby soils have been discussed under Shelby loam, sloping phase.

Shelby loam, strongly sloping phase (12–19% slopes) (Slt).—The profile of this phase is essentially the same as that described for the sloping phase, but slopes are greater. Areas that have been cultivated have lost practically all of their surface soil. In fact, any steep slope in the Shelby area that has been farmed is almost certain to be eroded. This strongly sloping soil is best suited to pasture, the use now being made of most of it.

Shelby silt loam, sloping phase (5–9% slopes) (Sbs).—This phase is one of the most variable soils in the county. In places it appears to be partly derived from loess and closely resembles Sharpsburg silty clay loam; in others it grades so gradually into Shelby loam soils it is difficult to locate boundaries between the two types.

Profile of uneroded Shelby silt loam, sloping phase:

0 to 10 inches, dark-brown silt loam with a soft fine blocky structure.

10 to 14 inches, dark-brown silt loam with a well-developed coarse granular structure.

14 to 24 inches, brown clay loam; plastic when wet but breaks into small hard irregularly shaped aggregates 1/8 to 1/4 inch in diameter when dry.

24 to 36 inches, dull-brown or yellowish-brown clay loam; plastic when wet.

36 inches +, yellowish-brown clay loam mottled with various shades of brown and gray.

Glacial pebbles are usually present in considerable number below about 30 inches. Lime concretions—small round soft white pebbles—are usually found below depths of 4 to 5 feet. The soil is medium acid down to the depth at which the lime concretions occur.

Use and management.—This soil is used in much the same way as the sloping phase of Shelby loam, and the problems of management are very similar. It is especially well suited to bluegrass. Some of the best bluegrass pasture in the county is on this silt loam near Maitland. When this sloping phase is cultivated it erodes rapidly, and, when eroded, it is similar to Shelby loam, eroded sloping phase.

Shelby silt loam, eroded sloping phase (6–12% slopes) (Sbe).—Except for having lost much of its surface soil through erosion, this soil is essentially the same as Shelby silt loam, sloping phase, in profile characteristics.

This soil is less productive than the sloping phase of Shelby silt loam. The present surface soil is low in organic matter and heavy enough in texture to be difficult to till. Some small grains can be grown on the less sloping areas, but the more steeply sloping eroded areas are best suited to grasses and hay crops. For information on use and management of this soil refer to the discussion of use and management given in the description of Shelby loam, sloping phase.

Steep stony land (Mandeville soil material) (20–50% slopes) (StM).—This land type occupies steep slopes in the southern part of the county and has formed from partly weathered limestone and shale. Slopes are steep. The soil material is shallow over rock; it

consists of 4 to 10 inches of brown silt loam or silty clay loam that usually contains fragments of limestone and shale. Small areas with 2 feet or more of material over the rock are included.

The land was originally forested with mixed hardwoods, but most of it has been cut over and is now fenced and used both for pasture and forest. Many areas would be more valuable if they were not grazed and used only as farm woodlots.

Wabash clay (0–1% slopes) (Wc).—This dark heavy-textured soil occurring mostly on the Missouri River flood plain has developed from alluvium. It differs from Cass Soils in having a heavy clay subsoil instead of a sandy one. In the Missouri River bottom the Wabash soils blend into Cass clay, and from surface appearance there is little difference between them. The Cass clay, however, has sand at an average depth of about 20 inches.

Profile description:

0 to 12 inches, dark-brown to black clay; very plastic when wet but has coarse granular structure when dry.

12 to 18 inches, material slightly lighter colored but otherwise similar to that in layer above.

18 to 30 inches, dark-gray or "steel-gray" plastic clay.

30 inches +, dark-gray clay with brown spots.

The soil is slightly acid, but lime is not required for growing legumes. Overflows occur during extremely high water. Internal drainage is very slow, and in most areas surface drainage is slow.

Use and management.—Like Cass clay, almost all of Wabash clay is cultivated, mainly to wheat. Cultural practices are the same as for Cass clay, and yields are about the same. Both soil types are well suited to soybeans where that crop can be grown in rotation with wheat. Corn does not grow well, for the soil is cold and wet early in spring.

Wabash clay, ponded phase (0–1% slopes) (Wcp).—This phase, one of the most extensive bottom land soils in the county, occupies the lowest position in the flood plain along the Missouri and lower Nodaway Rivers. The largest area is in a marsh formerly known as Impassable Lake. This marshy area extends from near the point where Little Tarkio Creek enters the Missouri flood plain to just west of Forest City. It is about 3 miles wide at the maximum and includes most of the 8,000-acre Squaw Creek Migratory Waterfowl Refuge.

At the time of settlement the area of heavy marsh land was more extensive. Information obtained while making the soil survey leads to the estimate that at least 18 square miles of former marsh land has been covered with several feet of brown, silty, hill wash within the past 75 years. The process is still taking place rapidly, and it is not improbable that most of this marsh area will be silted within the next 50 years.

The principal area of this soil along the Nodaway River covers about a square mile. The Nodaway River has been straightened by a canal dug to a point just east of New Point, and floodwaters come down this canal much faster than they did down the channel before straightening. The result has been ponding of floodwaters in the wide valley above New Point and the deposition of sediments. Deposition continues to take place rapidly along the Nodaway River, and in the area

influenced by that river this phase may be altered significantly within a few years.

This ponded phase is dark, heavy-textured, and very poorly drained. It is flooded at times by the Missouri River but mostly by streams such as Little Tarkio, Squaw, Davis, and Kinsey Creeks that drain into the basin from the surrounding upland. During wet seasons water stands on the surface for long periods.

The surface soil is of clay or silty clay texture; it varies from dark gray to black and is in places mottled with various shades of grayish brown. The subsoil, below about 12 inches, is a dark-gray very plastic clay. Included with this soil in mapping are several small depressions (old sloughs) along the Missouri River. These slough areas are in places underlain by sand at a depth of 3 feet or more.

Use and management.—About 15 to 25 percent of this ponded phase is cultivated, mainly to wheat. Most of the rest is idle or in pasture. Several areas brought into cultivation in the past have been abandoned because of repeated flooding.

Wabash silt loam (0–6% slopes) (Ws).—The individual tracts of this soil occur mainly along smaller streams in the region of Marshall and Shelby soils and are seldom more than an eighth of a mile wide. Several areas are in the Nodaway River bottom, and a few are in the Missouri River bottom.

Profile description:

0 to 12 inches, dark-brown or black mellow fine granular silt loam.

12 to 24 inches, dark-brown friable silt loam of well-developed coarse granular structure.

24 to 36 inches, dark-gray silty clay loam with a well-developed fine blocky structure.

36 inches +, dull-gray silty clay loam mottled with yellowish-brown stains.

The surface soil varies in appearance because varying amounts of sediments have been deposited recently. Where the deposit has been sufficient to greatly alter the soil, the area altered is shown as another type, McPaul silt loam. In a few areas along the Nodaway River the lower subsoil is silty clay.

Use and management.—This soil is very productive and is cultivated wherever the areas are not too small or irregularly shaped. Bluegrass makes vigorous growth. Most of the soil is flooded annually, but only for a few hours at a time and not so seriously as to affect use.

Wabash silty clay loam (0–1% slopes) (Wl).—Many small areas of this soil occur along the Nodaway River, and a few occur in the Missouri River bottom. Like all soils in the Nodaway River bottom, this one has received considerable deposition in recent years. The surface soil is therefore somewhat lighter colored and the profile more variable than for other Wabash soils.

Profile description:

0 to 12 inches, dark-brown to brownish-gray friable silty clay loam with a well-developed medium granular structure.

12 to 18 inches, dark-gray silty clay loam with a well-developed fine blocky structure.

18 inches +, dark-gray silty clay loam.

The entire profile is slightly acid, and it may contain streaks and lenses of coarser material throughout.

Use and management.—Most of this soil is cultivated, principally to corn. Corn produces high yields when not damaged by flooding. Generally the damage from overflow is less in the upper part of the Nodaway River Valley than in the lower.

USE AND MANAGEMENT OF IMPORTANT GROUPS OF SOILS

At least 12 elements necessary for plant growth are taken up from the soil. These are nitrogen, phosphorus, potassium, calcium, magnesium, manganese, sulfur, iron, boron, copper, zinc, and molybdenum. All of these elements must be present in the soil in available forms if plants are to grow. In most midwestern soils the first four—nitrogen, phosphorus, potassium, and calcium—are most likely to become deficient first when the soils are put to agricultural use.

One of the important problems of good soil management is the addition of fertilizers, lime, and organic matter to replace plant nutrients removed by cropping and to raise the level of plant-nutrient supply. The amounts and kinds of fertilizer and lime needed by a particular soil are influenced by the nature of that soil, the kind of crops to be grown on it, and its management history. The best way to determine the amounts of fertilizer and lime to use is that of obtaining soil tests through the county agricultural agent. Soil tests, interpreted by an agricultural specialist, are the most reliable means of determining how much and what kind of fertilizer to use.

Nitrogen accumulates only in the organic matter, which is also a source of some phosphorus. Organic matter consists of decomposing vegetation, and most of it is in the surface soil. Under continuous cropping or through erosion, the original supply of organic matter is reduced to a low level. If productivity is to be maintained, nitrogen must be returned to the soil in some form. Much of it should be returned in organic matter, as it improves the tilth and water-holding capacity of the soil. Nitrogen can be returned to the soil by applying barnyard manure, by growing legumes such as alfalfa, clovers, lespedeza, beans, and peas, and by applying commercial fertilizer. The choice of method depends on the farm enterprise. Generally, the supply of manure on farms is not adequate to maintain nitrogen and organic matter in the soil, so sod crops consisting of legumes and grasses are included in the cropping sequence. Legumes are able to obtain some of their nitrogen from the air, and, if plowed under, a legume (sweetclover for example) will increase the supply of nitrogen for the succeeding crops.

The calcium, potassium, and a considerable part of the phosphorus are furnished to plants from the inorganic (mineral) part of the soil. Most legumes require more calcium than do the nonlegumes such as corn and wheat; therefore, part of the process of building up productivity is that of supplying calcium in the form of ground limestone to those soils too low in that element for successful growth of legumes.

The management of individual soils has been discussed in the preceding section describing the soils. In the following pages the soils

of the county similar in management problems are grouped, and the capabilities and limitations of each group are discussed.

Undulating dark-colored soils of upland prairies (derived from loess.)—The soils of this management group are the following:

Marshall silt loam, undulating phase
Marshall silt loam, undulating brown phase
Sharpsburg silty clay loam, undulating phase

These loess-derived soils were originally high in organic-matter content and had relatively large supplies of calcium, phosphorus, and potassium. The undulating brown phase still has sufficient calcium for growing all legumes. The undulating phases of Marshall silt loam and Sharpsburg silty clay loam will support alfalfa or sweetclover without liming, but the chances of getting a stand are greatly improved if some lime is added. Without treatment, the undulating phase of Marshall silt loam supports a better growth of alfalfa or sweetclover than the undulating phase of Sharpsburg silty clay loam.

Slopes range from 1 to 7 percent. Some erosion takes place when these ridges are cultivated, but it has not been severe. Almost all erosion can be controlled by farming on the contour and by keeping the soils covered with vegetation in winter.

Fertility is also relatively easy to maintain. A green-manure crop or a liberal application of barnyard manure every 2 or 3 years should keep these soils at a high level of productivity. Periodic soil tests will reveal whether or not yields of corn can be increased by using nitrogen fertilizer. An application of nitrogen may improve corn yields even though a legume crop has preceded.

To insure good growth of legumes, the Sharpsburg soil should be limed, and possibly the undulating Marshall soil. About 2 tons of 10-mesh limestone an acre applied every 8 or 10 years should be sufficient. With long-continued or unusually heavy cropping, shortages of phosphorus and potash may develop. If yields decline, soil tests should be made and the fertilizer added according to the results of these tests.

Sloping dark-colored soils of upland prairies (derived from loess).—In this group are the following soils:

Marshall silt loam, sloping phase
Marshall silt loam, sloping brown phase
Sharpsburg silty clay loam, sloping phase

These sloping soils are much more extensive than the undulating loess-derived soils of the upland prairies. Their original fertility and productivity are equal to those of the undulating loess-derived soils but more difficult to maintain. No large areas were severely eroded at the time of survey, but erosion was taking place rapidly under the cultural practices commonly used.

Even under the most careful management there will be some erosion loss if these sloping soils are cultivated. Use of proved cultural practices such as terracing and contour listing and maintaining a vegetative cover throughout most of the year will reduce erosion losses. If the soils are kept at a high level of fertility, the resulting rank growth of vegetation will aid in controlling erosion. Fertility can be maintained by using manure or green-manure crops and supplying fertilizer and lime as soil tests indicate the need.

The bad effects of sheet erosion on these soils can be overcome largely by adding fertilizer and organic matter. Yields therefore can be

kept relatively high under good management, even on soils that have lost much of the surface soil.

Sloping dark-colored soils of upland prairies (derived from till).—The soils of this management group are the following:

Shelby loam, sloping phase
Shelby silt loam, sloping phase

These Shelby soils have a slope range of 5 to 12 percent. At the time of survey no large areas were severely eroded, but because of the management commonly used erosion was taking place.

The Shelby surface soil, even before erosion, is not so deep as that of the Marshall soils. In addition the Marshall soils have an open permeable subsoil, whereas the Shelby have a subsoil only slowly permeable. Tests made at Clarinda, Iowa on fallow Marshall and Shelby soils of comparable slope in the period 1934–41 show that 16 percent of the rainfall was recovered as percolate from Marshall soils and only 4 percent from Shelby soils. Percolation is therefore four times as great in Marshall as in Shelby soils. Since less water sinks into Shelby soils, more is left on the surface to run off and cause erosion.

Shelby soils not only tend to erode more rapidly than Marshall soils but are also much more seriously damaged by erosion. All available evidence indicates that erosion of Shelby soils results in a permanent loss of productivity. Eroded Shelby soils are decidedly less productive of common grain and forage crops than those not eroded.

It is very important that erosion be controlled on areas of Shelby soils not yet eroded. This is most easily done by raising the level of fertility by use of fertilizers and lime and by keeping a vigorous plant cover on them throughout the year. Alfalfa-bromegrass mixtures and other adapted forage crops will bring high returns on Shelby soils if fertility needs shown by soil tests are met and careful management is practiced. If these sloping soils are to be used for corn, the land should be terraced, farmed on the contour, the soil fertilized according to test, and the crop grown in a rotation that includes legume meadow.

Eroded sloping to strongly sloping soils of upland prairies (derived from loess).—The soils of this group are the following:

Marshall silt loam, eroded sloping phase
Marshall silt loam, eroded strongly sloping brown phase
Sharpsburg silty clay loam, eroded sloping phase

Erosion has removed most of the surface soil from these phases and, with it, the greater part of their nitrogen and organic matter. Having lost the high organic-matter content that makes for better structure, easier tillage, and greater absorption and retention of rainfall, these soils are harder to till and have less water-holding capacity than those uneroded. The subsoils now exposed are heavy silt loams and clay loams, not so easy to till as the original surface soils but not too heavy for cultivation.

If the nitrogen supply in the subsoils is increased and other plant nutrients are supplied, these soils can be made productive again. Treatments will be wasted, however, if these soils are allowed to erode rapidly in the future. Erosion control practices must accompany soil treatments.

Most areas are on slopes ranging from 8 to 15 percent; consequently erosion is harder to control than on the same kinds of soils with slopes

less steep. If they are to be used for clean-tilled crops, these soils should be terraced and farmed on the contour. Terraces, however, are difficult to build and to maintain on slopes greater than 10 percent.

Eroded sloping soils of upland prairies (derived from till).—The soils of this management group are the following:

Shelby loam, eroded sloping phase	Shelby silt loam, eroded sloping phase

These Shelby soils have lost most of their surface soil through erosion, and as the organic matter and nitrogen were mostly in the surface soil, they are low in both. Organic matter, aside from being a source of nitrogen needed by plants, improves soil structure, makes tillage easier, and increases the amount of water the soil can absorb and hold. These eroded Shelby soils are therefore harder to till and have more runoff and less water-holding capacity than the uneroded. The material now exposed on these eroded soils was originally the subsoil, which tends to be very hard and cloddy when dry, sticky and plastic when wet, and much more difficult to till than the original surface soil.

If plants are to be grown successfully on these eroded soils, the nitrogen supply in the subsoil material now exposed must be increased. Adding nitrogen and other plant nutrients in short supply will increase productivity. By applying necessary lime and fertilizer fairly good yields of forage crops can be obtained, though it will usually be unprofitable to attempt growing corn. Production on these soils probably will continue to be less than on the soils not eroded.

If these soils are allowed to erode rapidly in the future, soil treatments will be largely wasted. It is therefore important that erosion control measures accompany soil treatments.

Strongly sloping soils of upland prairies.—In this group are one soil phase and one miscellaneous land type:

Moderately steep land (Shelby soil material	Shelby loam, strongly sloping phase

These areas occur on slopes ranging from 12 to 19 percent. Erosion is very difficult to control if the land is cultivated. Most of the land is in pastures. The areas that have been cultivated are severely eroded.

The eroded areas of Shelby loam, strongly sloping phase, should be limed, fertilized, and seeded to grass-legume mixtures. Treatment for eroded areas of Moderately steep land (Shelby soil material) should be the same as for the Shelby loam, except no lime is needed. Strongly sloping areas now in grass should be left in grass; those not in grass should be seeded to an adapted grass-legume mixture.

Sloping brown soils of forested uplands.—The soils of this group are the following:

Knox silt loam, sloping light-textured subsoil phase	Knox silt loam, sloping phase
	Mandeville silt loam, sloping phase

These soils can be used for crops but are moderately low in organic matter and must receive nitrogen if present rather low yields are to be increased. The sloping light-textured subsoil phase of Knox silt loam does not require additional lime for alfalfa or sweetclover; the other soils do.

The areas of these soils that are on slopes favorable to cultivation are small and irregularly shaped. Many of them are too small to be farmed separately, and because surrounding slopes are usually best suited to pasture or hay, they are used for those crops. These soils are suited to special crops such as tobacco and tomatoes. Rotations consisting of small grains and legume-grass mixtures are also well adapted.

Strongly sloping brown soils of forested uplands.—The total acreage of this group is comparatively large. The soils are the following:

Knox silt loam, strongly sloping light-textured subsoil phase
Knox silt loam, strongly sloping phase
Mandeville silt loam, moderately steep phase

The strongly sloping phase of Knox silt loam and the Mandeville soil have a moderate supply of lime, phosphorus, and potassium. The strongly sloping light-textured subsoil phase of Knox silt loam is high in lime and other mineral nutrients. Slopes range from 9 to 20 percent.

Many areas of these strongly sloping soils have been and are being farmed. The uneroded areas are nearly all in pasture, which can be improved by adding nitrogen fertilizer or barnyard manure. The eroded areas should be seeded to a grass-legume mixture for hay and pasture. Sweetclover grows well on the eroded areas of Knox silt loam, strongly sloping light-textured subsoil phase. Alfalfa-bromegrass and alfalfa-timothy mixtures do well on these soils.

Steeply sloping soils.—The following are in this group:

Hamburg very fine sandy loam
Knox silt loam, steep light-textured subsoil phase
Steep stony land (Mandeville soil material)

These soils are best used for pasture or timber. The Hamburg soil, too steep for cultivation, supports mainly a grass cover, but in some of the more sheltered areas it is partly forested. If Hamburg soil is not overgrazed it does not present a serious management problem. The Knox soil, on slopes of 19 to 30 percent, is so steep that grass may not prevent erosion. A forest cover may be required. The Steep stony land is now partly forested, but most forested areas are pastured. Forested areas could be used more profitably if pasturing were stopped and the land were used only as farm woodlots.

Dark-colored well-drained soils derived from local alluvium.—The following soils are in this group:

Napier silt loam, gently sloping phase
Napier silt loam, sloping phase

These are medium-textured rapidly permeable soils, high in fertility and well suited to crop production. Corn, small grains, tobacco, truck crops, red clover, and sweetclover are all successfully grown.

Fine-textured soils of bottom lands not subject to frequent severe floods.—In this group are the following soils:

Cass clay
Cass silty clay
Wabash clay
Wabash silty clay loam

Soils of this group have slow surface drainage and, though highly fertile, are difficult to till and not well suited to corn. They are used

almost entirely for wheat, which is farmed on a large scale with tractor powered machinery. Only a small acreage of corn is grown, and that principally on Wabash silty clay loam. Alfalfa is grown on a limited acreage. A much larger acreage of soybeans could be grown on these heavy soils.

No attention has yet been given to maintaining soil fertility. Wheat is grown year after year. Usually the crop is combined, and the straw burned. Soil improvement practices such as use of fertilizer and green-manure crops will eventually be necessary to maintain yields.

Sandy well-drained soils of bottom lands not subject to frequent severe floods.—The only soil of this group is Sarpy loamy very fine sand, which is moderately fertile but too sandy to be highly productive of some crops. Most of this soil is used for small grains or special crops such as melons.

Soils of bottom lands subject to frequent severe floods.—In this management group are the following:

Riverwash
Sarpy loamy very fine sand, overflow phase
Sarpy very fine sandy loam, overflow phase
Wabash clay, ponded phase

Riverwash consists of bars along the Missouri River; it is mostly sandy, but all textures may be present. The textures as well as the boundaries may change whenever the river floods. This land has a limited value for pasture and timber production.

The overflow phases of Sarpy loamy very fine sand and Sarpy very fine sandy loam are slightly more stable than Riverwash. They lie on low bottoms in areas known as made land and are likely to be changed by floods. About half the acreage of these Sarpy soils is farmed, mostly to corn. The soils are fertile and, aside from the danger of flooding, suited to continuous cropping.

The ponded phase of Wabash clay lies in low heavy-textured areas that are for the most part too poorly drained for cultivation. Some wheat is grown on higher lying better drained areas, but the soil is essentially nonagricultural in its present state. The Squaw Creek Migratory Waterfowl Refuge covers most of the area.

Medium-textured soils of bottom lands not subject to frequent severe floods.—In this group are the most productive agricultural soils in the county:

Sarpy very fine sandy loam
McPaul silt loam
McPaul very fine sandy loam
Wabash silt loam

All of these soils are high in fertility, favorable to plant growth in physical properties, and easily tilled. Most areas have good surface drainage but are subject to occasional floods. Nevertheless, the flood hazard is not great enough to prevent cropping. Corn is the principal crop, and yields are high.

There is no serious problem in maintaining the fertility of these soils. Use of green manures or nitrogenous fertilizers, however, will usually increase yields. More adequate flood protection increases the value of these soils. When protected from floods, alfalfa and other legumes will grow on them satisfactorily.

ADDITIONAL FACTS ABOUT HOLT COUNTY

ORGANIZATION AND POPULATION

White settlement began in 1838, and in 1841 Holt County was organized. The population was 3,956 in 1850, 17,083 in 1900, and 9,833 in 1950. The decrease in population since 1900 has been general throughout the county but somewhat more pronounced in the northern part. The principal towns are Mound City, Oregon, Craig, Maitland, Forest City, Corning, Fortescue, and Bigelow.

ROADS AND OTHER FACILITIES

All-weather farm-to-market roads reach all sections but not all farms. According to census releases for 1950, 228 farms were on hard-surfaced roads, 505 on graveled roads, and 562 on dirt or unimproved roads. On the average, the farms were 5 miles from the trading center most frequently visited and 1.1 miles of this distance was over dirt or unimproved roads. Many of the unimproved roads are almost impassable in wet weather. Facilities for marketing farm produce and purchasing farm supplies are provided by the towns and smaller population centers.

Most farm homes are well built. Preliminary 1950 census figures list 912 farm dwellings with electricity, and 1,220 with telephones.

INDUSTRIES

Agriculture is the principal industry in the county, and almost all enterprises in the towns and marketing points are related to processing and marketing farm products or supplying the farm population with goods and services. Oregon has an apple packing plant, and Forest City a cannery.

AGRICULTURE

EARLY AGRICULTURE

Early settlements were made mainly along streams in the forested upland where supplies of wood and water were abundant. Agriculture developed steadily, largely on a self-sufficient basis, but a wide variety of crops were grown and some livestock and tobacco were marketed. Early transportation was by steamboat on the Missouri River.

The first railroad, now the Chicago, Burlington, and Quincy, was built into the county in 1869. After that agriculture developed rapidly. Artificial drainage of the bottom lands began in 1872 and still continues. Drainage of the bottom lands opened a large area for settlement between 1870 and 1900. During this period the area of improved cropland increased from 70,826 to 224,996 acres. With this 154,000 increase in acreage there was a decrease of only 20,000 acres of woodland in the same period. Much of the new cropland therefore had to be either prairie upland or drained prairie bottom land.

CROPS AND CROPPING PRACTICES

CORN

Corn is the principal crop in the county. In 1929 there were 73,752 acres in corn; in 1949 the acreage was 72,952. Practically all the corn crop is fed to livestock on the farm.

Corn is planted from the latter part of April to the 25th of May in lister furrows. A small part of the crop is cut for stover or silage, but most of it is harvested for grain after the ears have thoroughly dried in the field. Two-row listers, cultivators, and mechanical pickers are in common use.

WHEAT

Wheat has long been second to corn in acreage. The acreage of wheat increased in the period 1929–39 because that crop yielded better than corn in the drought years 1934 and 1936. Also, additional areas of the heavy Cass and Wabash soils were drained and machinery for large-scale wheat farming had been developed. The 1949 acreage of wheat, however, was slightly less than half the acreage in 1939. Most of the wheat is sold off the farm.

Land for wheat is plowed as soon after harvest as possible, or during the last part of July or in August. Wheat is seeded during late September and early October.

OATS

Oat crops are frequently used as a nurse crop for clover seedings. The seedbed is usually prepared by disking, and the oats are seeded either by drilling or broadcasting. Most fields are harvested with combines. The oat straw is frequently baled and used for forage and bedding.

HAY

Alfalfa, clovers, and timothy and clover mixed are the leading hay crop in the county. The acreages are shown in table 7. The general fertility of the soils of the county is indicated by the fact that fair yields of alfalfa and clovers are obtained without soil treatment under the management commonly used.

Alfalfa is grown without soil treatment on better drained river bottoms and on all the prairie soils of the upland. Land used for alfalfa is usually plowed early in summer, kept free of weeds by disking, and seeded in the last half of August.

The small acreage of sweetclover is used mainly for pasture but to some extent for hay. Sweetclover is particularly well adapted to the deep loess-derived soils. It should be remembered, however, that land left bare following second-year sweetclover tends to erode rapidly.

TABLE 7.—*Acreage of hay crops in Holt County, Mo., in stated years*

Crop	1919	1929	1939	1949
	Acres	*Acres*	*Acres*	*Acres*
Alfalfa	11, 034	7, 165	7, 035	8, 675
Clover and timothy, alone or mixed	6, 645	7, 973	1, 899	5, 777
Lespedeza	(1)	(1)	82	176
Small grains cut for hay	1, 185	309	1, 429	636
Other tame hay	132	69	991	176
Wild hay [2]	2, 879	214	203	131
Total	21, 875	15, 730	11, 639	15, 571

[1] Not reported.
[2] Decrease in acreage of wild hay due to conversion of swamp land to cultivation.

MINOR CROPS

Apples and peaches are the main fruit crops, and a small acreage is in plums, cherries, and pears, and grapes grown for market. According to preliminary census releases for 1950, the number of fruit trees and grapevines of bearing age in the county is as follows:

		Number
Apple	trees	2,960
Peach	do	6,735
Cherry	do	747
Plum	do	623
Pear	do	971
Grapevines		3,514

The number of fruit trees and grapevines has declined markedly because of late frosts, severe winters, drought, and poor markets. Commercial fruit growing is now confined to the deep fertile well-drained loess soils on the river hills well suited to that use.

Growing of bluegrass seed is of importance. Bluegrass seed was harvested from 526 acres in 1950. The yield was 49,187 pounds (green basis), or an average of 93.5 pounds an acre. The pastures are clipped with a mower late in summer to keep down weeds. Bluegrass is harvested with mechanical strippers and stacked in windrows for curing; the windrows are turned daily until thoroughly dried or cured.

PERMANENT PASTURE

Approximately half of all the permanent pasture is on hill land bordering the river bottoms. Most of this hill land is too steep for cultivation. Timber and brush remain on steeper slopes. This hilly land supports a varied growth, depending on management and soil conditions. Pastures range from good to poor. Canada bluegrass, Kentucky bluegrass, lespedeza, and, to some extent, big bluestem, little bluestem, and side-oats grama dominate among the grasses used in permanent pastures. Much of the Hamburg and Knox soil is too droughty for best growth of bluegrass.

Second to the hill land in acreage but seprior to it in quantity and grade of forage produced are the Shelby soils derived from gacial till in the northern part of the county. Bluegrass grows very well on Shelby soils where they are not eroded, but in old cultivated and eroded fields the pasture is of poorer quality and produces low yields.

Considered as a whole, the Marshall and Sharpsburg soils produce excellent bluegrass pasture. The brown phases of Marshall silt loam are a little too open for the best bluegrass growth, but some very good bluegrass pastures are found on them. The common practice on Sharpsburg and Marshall soils is to strip the bluegrass for seed and to pasture only in fall and early in spring. Pastures on these soils, especially those stripped for seed, have nearly pure stands of bluegrass.

LIVESTOCK

The numbers of livestock on farms are given in table 8 for stated years. Hogs on farms greatly increased in the period 1940–50.

Hampshire, Duroc, and Poland China are the principal breeds of hogs. Hereford cattle lead in number, but Shorthorn and Aberdeen Angus are also popular. Some beef cattle are raised in the county, but most of them are brought in as feeders in fall, fattened, and sold in spring and summer in St. Joseph, Kansas City, St. Louis, or Chicago. This is not a dairying county, but there were 4,896 cows

995955—53——4

milked in 1950. Dairy products provide an additional source of farm income, as do poultry and eggs. The sheep kept on farms are mostly Western-Hampshire crosses, or Western ewes bought on the market and bred to Hampshire rams. The lambs are fattened and sold, usually in summer.

TABLE 8.—*Number of livestock on farms in Holt County, Mo., in stated years*

Livestock	1920	1930	1940	1950
	Number	*Number*	*Number*	*Number*
Horses	7, 615	5, 826	[1] 3, 876	2, 049
Mules	3, 103	2, 674	[1] 1, 652	330
Swine	61, 269	78, 910	[2] 37, 844	72, 567
Cattle	22, 566	17, 919	[1] 18, 080	24, 120
Sheep	2, 507	5, 365	[3] 4, 859	3, 659
Chickens	256, 771	[1] 117, 873	[2] 133, 171	[2] 117, 512

[1] Over 3 months old, Apr. 1.
[2] Over 4 months old, Apr. 1.
[3] Over 6 months old, Apr. 1.

LAND USE

Census Bureau figures for 1949 show 60.5 percent of the harvested cropland in corn, 13.9 percent in wheat, 13 percent in hay, and 9.9 percent in oats.

TYPE, SIZE, AND TENURE OF FARMS

As classified by type in 1950, there were 870 livestock farms, 236 cash-grain farms, 70 general farms, 20 dairy farms, and 5 poultry farms. In that year there were 170 miscellaneous and unclassified farms.

The average farm size has increased from 139.8 acres in 1920 to 188.3 acres in 1950. In the same period the number of farms decreased from 1,814 to 1,371. The increase in average farm size is directly related to the decrease in number of farms and in the farm population. The trend toward fewer farms of larger size has been accompanied by more complete mechanization.

In 1950, 60.6 percent of the farms were between 70 and 259 acres in size. There were 271 farms 260 acres or larger and 269 farms 69 acres or smaller in size.

Tenants operated 32.4 percent of the farms in 1950. In that year there were 611 owners, 312 part owners, 4 managers, 20 cash tenants, 132 share-cash tenants, 250 share tenants and croppers, and 42 other unspecified tenants. Tenancy dropped considerably between 1940 and 1950.

FARM EQUIPMENT

The shift from horses and mules to tractor power has been gradual (see table 8, above). Most of the work stock is of fair quality and of mixed Percheron type. The 1950 census reported tractors on 931 farms, motortrucks on 418 farms, and automobiles on 1,075 farms. There were 1,370 farms in the county. Combines, mechanical corn pickers, and other labor-saving equipment are widely used.

WATER CONTROL ON THE LAND

Flood control and drainage have been serious problems since settlement of the county. In the period 1903–31, floods were reported on the Missouri River in 11 years, or about once every 3 years.

A considerable part of the damage has been caused by floodwaters from small streams. A number of drainage districts have been organized for straightening stream channels and building levees. The controls built have decreased the severity of floods on the small streams. The organized drainage and levee districts and the area, function, and effectiveness of each are shown in table 9.

TABLE 9.—*Organized drainage and levee districts*[1] *in Holt County, Mo.*

District	Area	Function	Adequacy
	Acres		
Corning Levee	2, 096	Retard flow	Poor.
Highland Drainage	2, 698	Straighten channel	Good.
Mill Creek Drainage	1, 729	Channel drainage (ditch)	Fair.
Big Tarkio Drainage	22, 856	Drainage and levee	Do.
Little Tarkio Drainage	4, 789	do	Good.
Nodaway District No. 1	5, 143	Drainage	Fair.
Squaw Creek Drainage	20, 000	Drainage and levee	(2).
Total	59, 311		

[1] Data on all Districts except the Squaw Creek from Missouri State Planning Board, Jefferson City, Mo. Data on Squaw Creek Drainage District from: WILLIAMS, WALTER. HISTORY OF NORTHWEST MISSOURI. 3 Vol., illus. 1915 Chicago and New York.
[2] No estimate available.

As mentioned in the discussion of McPaul silt loam (p. 30), levees and diversion ditches are sometimes built to flood the land rather than to prevent flooding. In some areas silt-laden water is held on the land by levees until the silt is dropped, and the water is then drained away. In this way approximately 23 square miles of marsh have been converted into extremely fertile cropland. The deposits washed from the hills have been made up principally of surface soil and owe much of their high fertility to this fact. This silting method of land reclamation is still in progress.

Flood control in the valleys is related to runoff control on the uplands. The change that has taken place in amount and type of runoff since settlement began cannot be measured, but some clues are contained in early descriptions of the area. All records indicate that streams once had a clear and more uniform flow. The streams had a larger flow in dry weather, and floods were less severe. The small drainageways were densely sodded marshy areas without definite channels in which a considerable part of the water moved by seepage. Seepage fed the larger streams during dry weather. At present the drainageways have deep steep-sided ditches or ravines that carry a large volume of water during rains and are dry the rest of the time. The lowering of the ground water table is one of the principal reasons so many springs and wells have gone dry in this county recently.

MORPHOLOGY, GENESIS, AND CLASSIFICATION OF SOILS

FACTORS OF SOIL FORMATION

Soil is the product of the forces of weathering and soil development acting on the parent material deposited or accumulated by geologic

agencies. The characteristics of the soil at any given point depend on (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and has existed since accumulation; (3) the plant and animal life in and on the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of development have acted on the material. The climate, and its influence on soil and plants, depends not only on temperature, rainfall, and humidity but also on the physical characteristics of the soil or soil material and on the relief, which, in turn, strongly influences drainage, aeration, runoff, erosion, and exposure to sun and wind.

PARENT MATERIAL

The four main types of parent material in this county are loess, glacial till, shale and thin-bedded limestone, and recent alluvium, or stream deposits. Loess so greatly influences soils of the county that it is separately discussed under the heading Loess as a Soil Material.

CLIMATE

The climate is essentially the same over the entire county. The average annual precipitation is 36.3 inches. The internal characteristics of the soils vary because of differences in soil materials, relief, drainage, and vegetative cover rather than because of variations in climate.

VEGETATION

Most of the upland soils developed under grass, as the county is in the Prairie soil region of the Central States. Upland areas with dominant slopes of less than 12 to 15 percent were in grass, those steeper, mainly in forest. The timbered upland soils have some characteristics of the Gray-Brown Podzolic soils, which are more typically developed farther east. An exception is the steep narrow band of treeless Hamburg soil on the bluff along the Missouri River flood plain. Differences in the upland vegetative cover probably result from differences in relief.

RELIEF

Relief, aside from its influence on the type of vegetation, is reflected principally in differences in depth of surface soil. Surface soils on steep slopes were originally shallower than those on ridge tops, and since cultivation this difference has been increased by erosion.

TIME

Soils of this county on steep hillsides and alluvial flood plains have properties determined almost wholly by the properties of the parent material. They have not been exposed to weathering a long enough time or in great enough intensity to show the influence of the other factors of soil formation.

CLASSIFICATION OF SOILS

The soil series of the county are placed in orders and great soil groups as shown in the following tabulation:

Zonal:
- Prairie:
  - Marshall.
  - Napier.
  - Sharpsburg.
  - Shelby.
- Gray-Brown Podzoilc (prairie-forest transition):
  - Knox.
  - Mandeville.

Intrazonal:
- Humic-Gley:
  - Wabash.

Azonal:
- Lithosol:
  - Hamburg.
- Alluvial:
  - Cass.
  - McPaul.
  - Sarpy.

PRAIRIE GREAT SOIL GROUP

The Prairie soils have dark-brown medium-textured surface soils and slowly to rapidly permeable subsoils. The Marshall (fig. 9), Napier, Sharpsburg, and Shelby soils are in this group. The Marshall and Sharpsburg soils have developed from loess; the Shelby, from

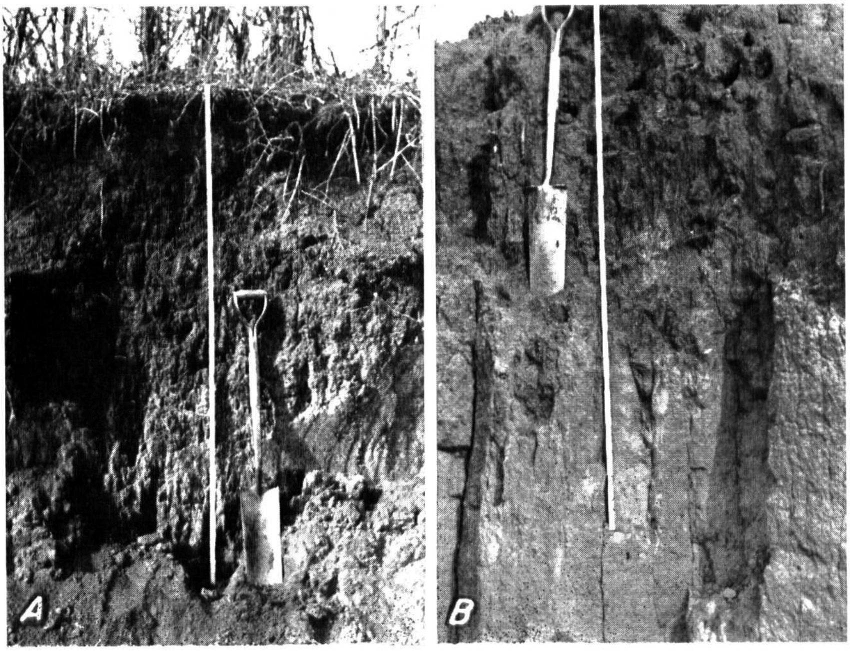

FIGURE 9.—*A*, Profile of Marshall silt loam, undulating phase; *B*, Profile showing columnar structure of Marshall silt loam, undulating brown phase.

glacial till; and the Napier, from local alluvium. Marshall silt loam is representative of soils in this group. The following is a profile description of Marshall silt loam, undulating phase, taken from a pit in a cornfield on a 3 percent slope in section 19; township 61, north; range 37, west:

A_1 0 to 6 inches, weak-brown (dry) to dusky-brown (moist) very friable silt loam; well-developed fine crumb structure.

A_3 6 to 12 inches, weak-brown (dry) to dark-brown (moist) friable silt loam; well-developed medium granular structure; material dark yellish-brown when structure particles are crushed.

B_1 12 to 18 inches, moderate-brown (moist) friable silt loam with fine subangular blocky structure; material moderate yellowish-brown when structure particles are crushed.

B_2 18 to 24 inches, moderate-brown (moist) friable silt loam with weak medium subangular blocky structure; material moderate yellowish-brown when structure particles are crushed.

B_{31} 24 to 30 inches, texture a little coarser but layer essentially the same as that immediately above.

B_{32} 30 to 36 inches, moderate yellowish-brown (moist) very friable silt loam; some spots of pale brown and a few flecks of strong brown; structure particles weakly developed fine granules.

C 36 to 48 inches, light yellowish-brown (moist) very friable silt loam of massive structure; shows a few spots of pale brown.

There are no sharp boundaries between the various horizons, and the texture of all horizons is essentially the same (table 10). The organic content and color have the same profile distribution; that is, color is darkest and organic content is highest in the surface layer. The base saturation and the pH increase with depth, indicating a moderate amount of leaching from the surface horizons (table 11). The structure particles are largest and best developed between 18 and 24 inches.

TABLE 10.—*Mechanical analyses*[1] *of Marshall silt loam, undulating phase, Holt County, Mo.*

Sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
346454	0–6	0	0	0.1	0.2	3.4	66.6	29.7
346455	6–12	0	0	.1	.2	3.4	66.2	30.1
346456	12–18	0	.1	0	.2	3.3	66.5	29.9
346457	18–24	0	.1	.1	.3	4.4	66.1	29.1
346458	24–30	0	0	.1	.3	4.2	69.0	26.4
346459	30–36	0	.1	0	.3	4.6	68.5	26.6
346460	36–48	0	0	0	.3	4.9	68.6	26.2

[1] Mechanical analyses show this soil belongs in the silty clay class, but its "silt loam" name was retained because of long-established usage and the fact the brown phases of this soil type are coarser textured and well within the silt loam textural class.

TABLE 11.—*Chemical analyses of Marshall silt loam, undulating phase, Holt County, Mo.*

Sample No.	Depth	Organic matter	pH	Moisture equivalent	Exchange capacity	Exchangeable hydrogen	Base saturation
	Inches	*Percent*		*Percent*	*Milliequivalents per 100 grams*	*Milliequivalents per 100 grams*	*Percent*
346454	0–6	3.0	5.7	27.5	20.1	7.8	61
346455	6–12	2.6	5.9	26.2	17.2	6.6	62
346456	12–18	2.3	6.0	27.4	18.2	6.6	64
346457	18–24	1.4	6.0	27.5	19.5	6.0	69
346458	24–30	.6	6.3	27.5	20.1	5.4	73
346459	30–36	.7	6.3	27.5	19.0	5.1	73
346460	36–48	.2	6.4	27.9	19.0	4.1	84

GRAY-BROWN PODZOLIC GREAT SOIL GROUP

Two soil series of this county, the **Knox** and **Mandeville**, show some of the characteristics of Gray-Brown Podzolic soils. They have developed under forest vegetation, but prairie vegetation probably has been abundant enough in the timbered areas to have some effect on soil development. The light-textured subsoil phases of Knox silt loam are the most extensive soils in this group. They have developed from deep loess on rolling to hilly areas. The native vegetation consists of elm, walnut, ash, maple, and oak. The following profile was taken on a narrow rounded ridge half a mile north of Kimsey School in Holt County.

A_1 0 to 8 inches, weak-brown (moist) very friable silt loam with a moderate fine granular structure.

A_3 8 to 15 inches, moderate-brown (moist) friable silt loam with a weak fine subangular blocky structure; structure particles crush to moderate yellowish-brown material.

B_2 15 to 30 inches, light-brown to moderate-brown (moist) friable silt loam of weak medium subangular blocky structure; structure particles crush to moderate yellowish-brown material.

C 30 to 40 inches, light yellowish-brown (moist) very friable silt loam; massive structure; some spots of pale brown and very pale brown.

From data presented in tables 12 and 13 it is evident that the light-textured subsoil phases of Knox soils are not strongly leached. The pH indicates that the soils are nearly neutral, and the exchange complex is nearly saturated. There is a definite zone of lower saturation in the subsoil at about the same depth as that at which most of the clay is found. The organic-matter content is lower in the Knox surface soil than in the Marshall. Also, the Knox surface is shallower than that of the Marshall.

TABLE 12.—*Mechanical analyses of Knox silt loam, light-textured subsoil phases, Holt County, Mo.*

Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0–6	0	0. 1	0. 2	0. 9	6. 9	72. 6	19. 3
6–12	0	. 1	. 1	. 5	6. 5	69. 3	23. 5
12–30	0	. 1	. 1	. 3	5. 9	66. 9	26. 7
30–48	0	0	. 1	. 3	5. 8	69. 2	24. 6
48–60	0	0	. 1	. 3	6. 7	72. 8	20. 1
60–70	. 1	. 1	. 2	. 9	8. 7	72. 2	17. 8
Feet							
11½	0	. 1	. 1	. 4	7. 3	75. 9	16. 2

TABLE 13.—*Chemical analyses of Knox silt loam, light-textured subsoil phases, Holt County, Mo.*

Depth	Organic matter	pH	Exchange capacity	Exchangeable hydrogen	Base saturation
Inches	*Percent*		*Milliequivalents per 100 grams*	*Milliequivalents per 100 grams*	*Percent*
0–6	2. 5	7. 6	16. 0	2. 2	87
6–12	1. 0	7. 5	12. 5	2. 4	81
12–30	. 7	6. 3	14. 0	4. 3	69
30–48	. 4	5. 9	13. 0	4. 4	66
48–60	. 2	6. 1	13. 5	3. 0	78
60–70	. 1	6. 3	12. 5	2. 2	82
Feet					
11½	. 1	8. 2	10. 5	0	100

LOESS AS SOIL MATERIAL [6]

The influence of loess on the soils of this county becomes evident on study of table 14. The table gives the approximate thickness of the loess cover at various distances from the source—the flood plains along the Missouri River. Profile numbers key the table to figure 10, which shows the soil associations of the county. It is apparent from table 14 that the loess thins rapidly as the distance from its source increases. The depth of the loess is a function of the log of the distance from the source.

Along with the thinning of the loess deposit there is a decrease in the average size of particles. In figure 11 particle size is plotted

TABLE 14.—*Approximate thickness of loess deposit at various distances from the Missouri River bluff, Holt County, Mo.*

[Profile numbers key this table to fig. 10, which shows where profile examinations were made]

Soil and profile No.	Distance from edge of bluff	Approximate thickness of loess
Hamburg very fine sandy loam:	*Miles*	*Feet*
190	0. 1	80–100
191	. 3	60–80
Knox silt loam, light-textured subsoil phase:		
201	1. 0	40–60
200	1. 6	40–50
Marshall silt loam:		
Undulating brown phase:		
230	4. 0	20–25
231	4. 0	20–25
Undulating phase:		
240	6. 5	11–14
241	6. 5	10–12
Sharpsburg silty clay loam:		
251	9. 0	8–11
250	13. 0	7–9

[6] This section based on work of M. E. Springer, Missouri Agricultural Experiment Station.

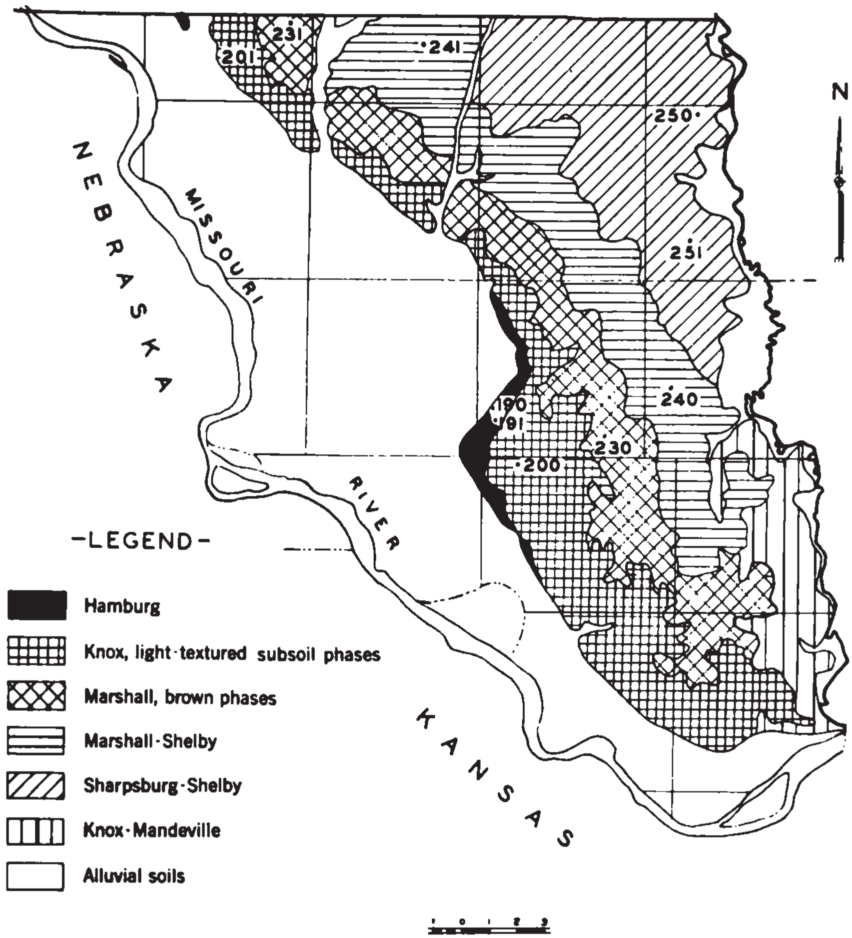

FIGURE 10.—Soil associations of Holt County, Mo., and locations for samples listed in table 14.

against distance from the bluff in four size ranges—0.05 to 0.1 millimeter, 0.02 to 0.05 millimeter, 0.002 to 0.02 millimeter, and less than 0.002 millimeter. At a distance of 0.3 mile from the source, the loess contains 12 percent very fine sand (0.05 to 0.1 millimeter) and 10 percent clay (less than 0.002 millimeter). The percentage of very fine sand drops rapidly until an approximate distance of 1½ miles from the source is reached and from there on changes gradually. The percentage of clay increases rapidly to a point about 1½ miles from the bluff and from that distance increases gradually. At 9 miles from the bluff the loess contains only 2 percent very fine sand but 27.4 percent clay. The trend for the 0.02- to 0.05-millimeter size range resembles that for the very fine sand; the trend for the 0.002- to 0.02-size range resembles that for the clay. The percentage of coarses particles decreases and the percentage of finer particles increases as distance from the source become greater.

As might be expected, the differences in composition of the loess are reflected in the horizons of the various soil types. This is brought out in figure 12, which shows that the clay content of each horizon increases with increased distance from the source of the loess. Nevertheless, except for the Hamburg soil, the profiles of all soils studied have horizons similar in degree of development.

A study of the quartz content in the silt fraction of the loess was made. The quartz contents in the coarser silt (0.02 to 0.05 millimeter) and finer silt (0.005 to 0.02 millimeter) are plotted in figures 13 and 14, respectively. For the parent loess, the content of quartz in the

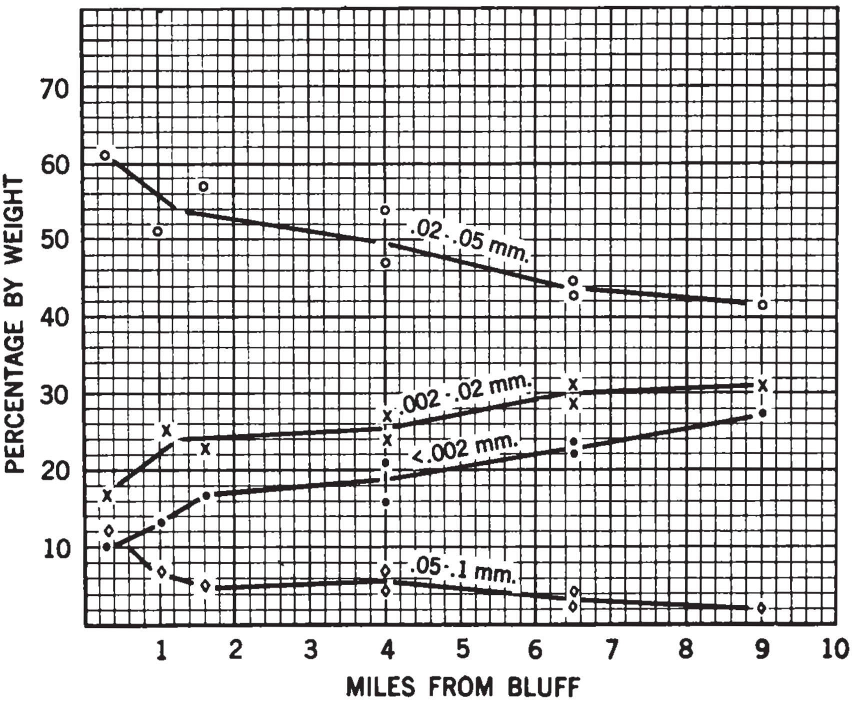

FIGURE 11.—Particle-size distribution in loessal parent material plotted against distance from the Missouri River bluff.

0.02- to 0.05-millimeter silt remains relatively constant at all locations, but the content of quartz in the 0.005- to 0.02-millimeter silt is slightly lower 1.6 miles from the source than at locations farther distant.

Quartz contents in the surface soil silt are also plotted in figures 13 and 14. Near the bluff, that is in the Hamburg soil area, the silt of the surface soil and parent loess is similar in quartz content, but in the other soils farther from the bluff the silt has appreciably more quartz in the surface soils than in the parent loess. This indicates that all the loess soils except the Hamburg have lost appreciable quantities of minerals other than quartz through weathering.

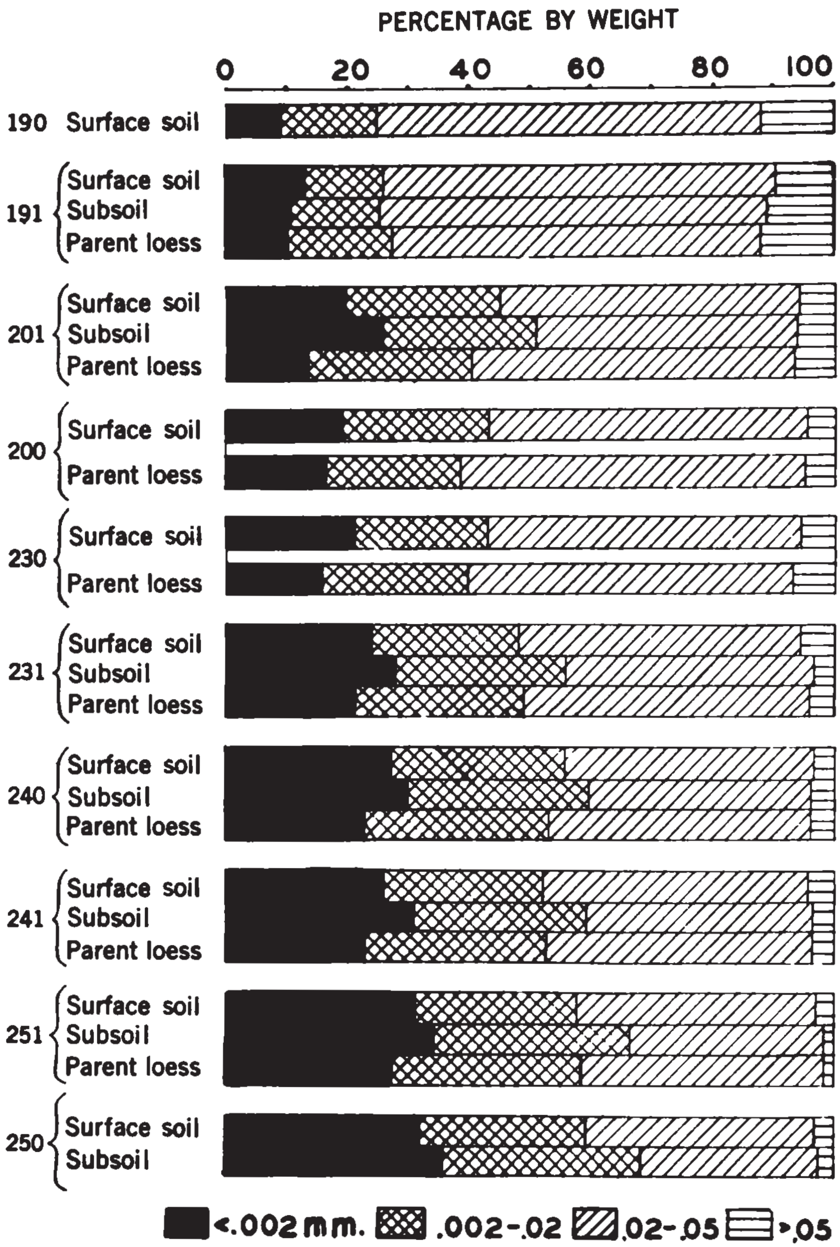

FIGURE 12.—Composition of surface soil, subsoil, and parent loess at sampling sites shown in figure 10.

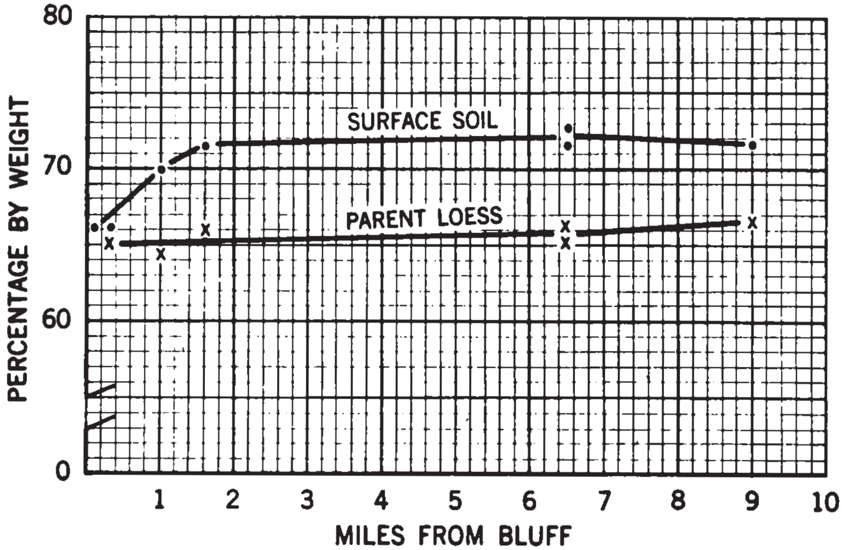

FIGURE 13.—Quartz content in 0.02- to 0.05-millimeter silt plotted against distance from the Missouri River bluff.

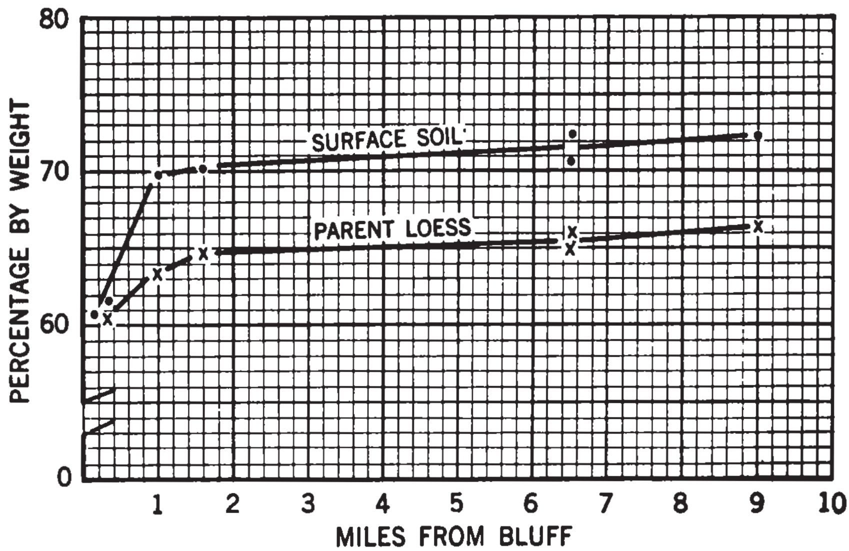

FIGURE 14.—Quartz content in 0.005- to 0.02-millimeter silt plotted against distance from the Missouri River bluff.

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the identification, classification, and mapping of soils in the field. The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures such as those in road cuts or mine cave-ins are studied. Each excavation exposes a series of distinct soil layers, or horizons, called collectively the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail. The color, structure,

porosity, consistence, texture, and the content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [7] and its content of lime and salts are determined by simple tests. The drainage, both internal and external, and other external features, such as relief, or lay of the land, are taken into consideration; and the interrelation of the soil and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, special emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics, soils are grouped into classification units, the three principal ones of which are (1) series, (2) type, and (3) phase.

The most important of these groups is the series. The series includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the profile, and developed from a particular type of parent material. The series therefore includes soils having essentially the same color, structure, natural drainage conditions, and range in relief. The texture of the surface soil may differ within a series. Soil series are given names of places or geographic features near which they were first found. Hamburg, Marshall, and Shelby are familiar place names in this region, as well as the names of soil series in Holt County.

Within a soil series are one or more soil types defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, silty clay loam, silty clay, and clay, is added to the series name to complete the name of the soil type. For example, Sarpy very fine sandy loam and Sarpy loamy very fine sand are soil types within the Sarpy series. Except for the sand content in the surface soil, these two soil types have essentially the same characteristics.

Soils differing only in some minor characteristic that may have an important practical significance are separated into phases. Differences in relief or erosion are frequently shown as phases. The soil type and phase are the principal units of mapping, and because of their specific character they are usually the soil units to which agronomic data are definitely related.

The soil surveyor makes a map of the county or area showing the location of each of the soil types, phases, and miscellaneous land types in relation to roads, houses, streams, section and township lines, and other local cultural and natural features of the landscape.

Mapping in Holt County, Missouri, was done on aerial photographs which were printed on a scale of approximately 3 inches to the mile. Information was recorded on these aerial photographs, and this information was used to compile the map which accompanies this report.

Not all slope and erosion information recorded on the aerial photographs is shown on the published map. Copies of the aerial photographs showing the more detailed information are on file at the agricultural extension agent's office at Oregon, Missouri.

[7] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality; higher values, alkalinity; and lower values, acidity.

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To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at http://www.ascr.usda.gov/complaint_filing_cust.html and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by:

(1) mail: U.S. Department of Agriculture
Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, SW
Washington, D.C. 20250-9410;

(2) fax: (202) 690-7442; or

(3) email: program.intake@usda.gov.

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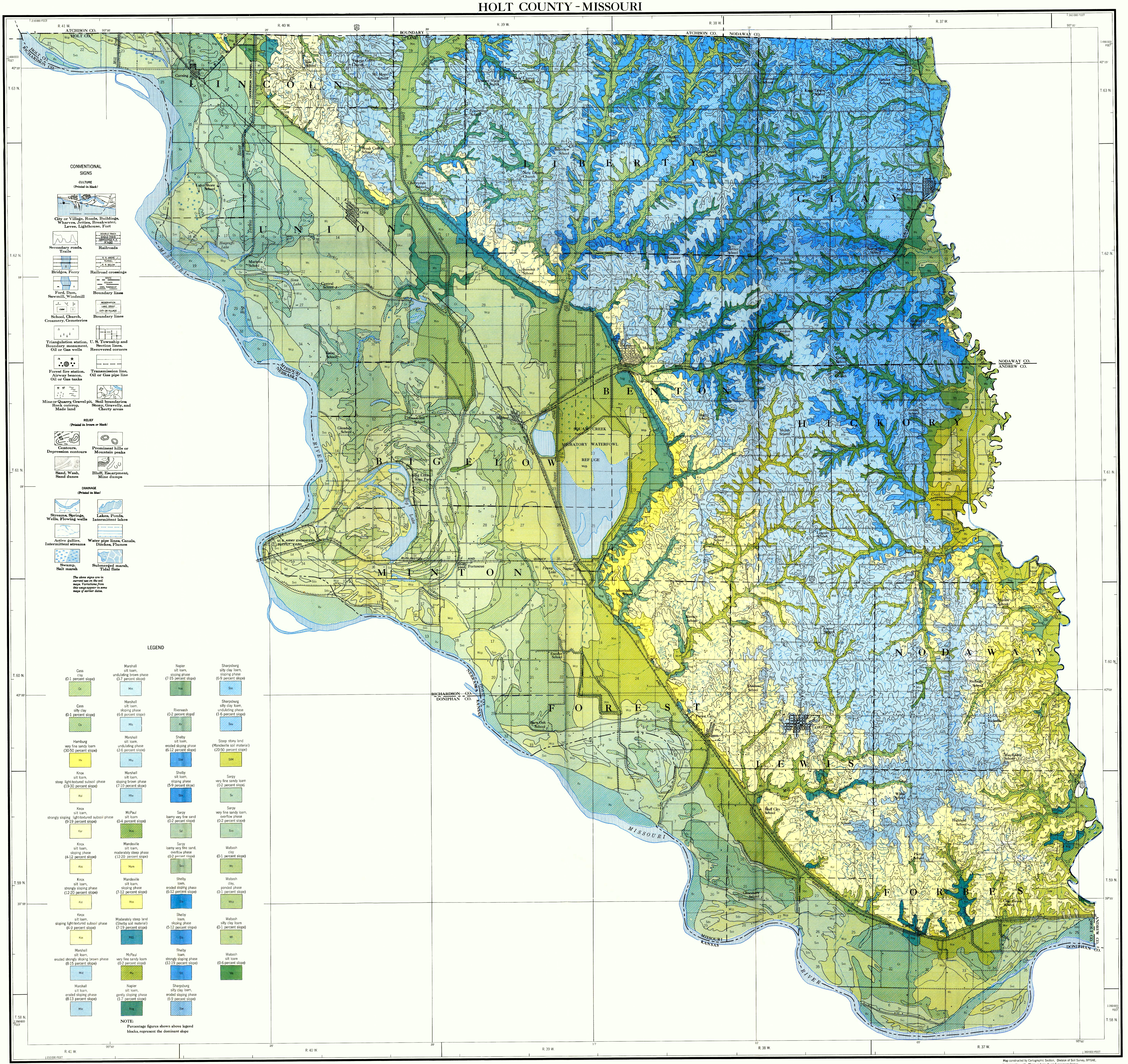
U. S. DEPARTMENT OF AGRICULTURE

SOIL MAP
HOLT COUNTY - MISSOURI

UNIVERSITY OF MISSOURI
AGRICULTURAL EXPERIMENT STATION



J. Kenneth Ableiter, Chief Soil Correlator.
C. P. Barnes, Chief Analyst, Soil Uses and Productivity.
Earl D. Fowler, Principal Soil Correlator, Northern States.
Inspection and correlation by Earl D. Fowler and A. M. O'Neal,
Senior Soil Scientist. Soils surveyed 1939, by W. D. Shrader, in Charge,
M. E. Springer, and N. S. Hall Missouri Agricultural Experiment Station.

Scale 1:63,360

Map constructed by Cartographic Section, Division of Soil Survey, BPISAE,
in cooperation with Missouri Agricultural Experiment Station.
H. W. Whitlock, Engineer, in Charge.
Polyconic Projection. 1927 North American datum.
Horizontal control by USGS.
Planimetry compiled from aerial photographs by photogrammetric methods.
Photography by U. S. Department of Agriculture, 1936. Field examination, 1939.
10 000 foot grid based on Missouri (West) rectangular coordinate system.